RUFFED GROUSE ECOLOGY AND MANAGEMENT IN THE APPALACHIAN REGION

Final Project Report of the
Appalachian Cooperative Grouse Research Project

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Ruffed grouse ecology and management in the Appalachian region

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EXECUTIVE SUMMARY

Ruffed grouse populations have been declining throughout the Appalachian region for several decades. The Appalachian Cooperative Grouse Research Project (ACGRP) was established in 1996 by state natural resources agencies in the region to investigate potential factors limiting ruffed grouse populations. Hunting, particularly late season impacts, has been suggested as a potential cause of declining grouse numbers. Additionally, wildlife managers have suggested that the quantity and quality of ruffed grouse habitats have declined in recent decades.

Initial study sites and cooperators included Ohio, Kentucky, West Virginia, Maryland, and Virginia. Subsequently, sites and cooperators were added in Pennsylvania, North Carolina, and Rhode Island. Cooperators included state natural resource agencies and university wildlife programs from each state. Regular meetings were held to ensure that data were collected consistently across all study sites; the synergistic nature of the project ensured that the overall findings resulting from 12 study sites in 8 states would be greater than what could have resulted from any individual study area. The objectives of the ACGRP were to:

1. estimate survival rates and identify limiting factors for ruffed grouse populations,
2. estimate reproductive rates and identify limiting factors to reproduction,
3. determine if harvest mortality is compensatory or additive, and
4. evaluate habitat selection and quality.

Data were collected on 3,118 ruffed grouse captured on the 12 study sites from September 1996 through October 2002. Our general results indicated that the ecology of Appalachian ruffed grouse differs from northern ruffed grouse populations (i.e., Great Lake States) where aspen offers good food and aspen forest management creates an abundance of cover. Adult survival tended to be higher in the Appalachians, but reproductive success was lower. Within the Appalachians, we found that grouse populations differed between areas dominated by mixed-mesophytic cover types and oak-hickory dominated sites. Specific, significant findings of the ACGRP include:

- Spring pre-breeding diets in Great Lake States ruffed grouse were dominated by aspen buds whereas in the Appalachians diets were more variable, with oak mast, herbaceous and evergreen leaves, and flowers being most prevalent. Appalachian diets tended to be of lower nutritional quality than that of northern birds feeding on aspen.

- The nutritional condition of females in the Appalachians prior to nesting was quite variable, and body fat levels showed a strong relationship to acorn availability, with higher body fat being found where acorns were available. When female body fat was less than 11% chick survival was lower.

- Cameras set on nests documented 5 nest depredation events by 3 species of mammals, and nest predation may impact overall nesting success.

- Nest success ranged from 52% to 87% across the sites and years studied. Successful nests tended to be over 100 m from openings in pole-size timber stands with dense understories.

- Chick survival was extremely low compared to studies from other areas. Chick survival to 35 days averaged 22%. Chick survival was higher on mixed-mesophytic sites (35%) than on oak-hickory dominated sites (21%).

- A radio-telemetry study of chick survival found that mortality of 118 chicks was evenly distributed between exposure (44%) and predation (44%).

- Nest and re-nest rates were lower in oak-hickory areas (86% and 3.2%, respectively) than in mixed-mesophytic sites (100% and 45%, respectively).

- Overall adult survival was 43% across all sites and years. Annual survival rates were higher on oak-hickory sites (50%) than mixed-mesophytic sites (39%). Survival was higher in the spring-summer period and lower in fall-winter, and did not differ between age or sex classes.

- We conducted a hunting experiment on 7 sites over the 6-year study. On 3 treatment sites hunting was closed the last 3 years of the study. These 3 sites had the highest hunting mortality rates during the first 3 years of the project. The other 4 sites served as control sites where hunting occurred throughout the study. Survival generally increased during the last 3 years of the experiment on both treatment and control study sites. However, we did not find evidence of an interaction effect or larger than expected increases in the treatment sites where hunting had been closed. We concluded that hunting mortality on these sites was compensatory. Hunting was only 12% of all mortality on average, and ranged from 0% to 35% across sites and years; we cannot conclude or infer that hunting would be compensatory at higher harvest rates.

- The primary cause of adult mortality was avian predation (44%) followed by mammalian predation (26%). A wide diversity of predators was observed on the study sites; only owls and Cooper's hawks sightings showed a relationship to predation rates of ruffed grouse.

- Ruffed grouse generally selected early successional habitats, or sites that had the high stem densities characteristic of early successional habitats. Females with broods selected sites that had higher than average herbaceous cover and greater arthropod abundance than random sites.

- Home ranges were calculated for 1,054 grouse based on 67,814 telemetry locations. Adult and juvenile females and juvenile males had larger home ranges than adult males. Females with broods had larger home ranges (39 ha) than females whose broods failed (15 ha). In oak-hickory sites, both female and male home ranges increased following years of acorn failure (20 ha to 52 ha in females and 7 to 27 ha in males).

Management suggestions include:

- Maintain current harvest levels and seasons; populations are not limited by current hunting levels.

- Increases in populations are most likely to come from habitat management. In mixed-mesophytic areas "traditional" early successional grouse management will likely be successful. This should emphasize using timber harvest techniques that will provide a diversity of young-aged stands interspersed among mature forests.

- In oak-hickory dominated sites, forest management should strive to provide both food (acorns) and cover (early successional habitat) needs of grouse in close proximity. Clearcutting, shelterwood, two-age, and group selection silviculture offers managers alternatives to create these contrasting needs of acorns from mature oak trees in association of cover from young stands.

- Roads can be managed by gating and planting preferred herbaceous foods to supplement existing natural foods.

INTRODUCTION

The ruffed grouse is a popular gamebird distributed from Alaska across central and southern Canada and the northern United States to the Atlantic Coast, south into the central Rocky Mountains and Appalachian Mountains. Its distribution coincides closely with that of aspen, except in the Appalachians. Throughout most of the range of the ruffed grouse, aspen is considered a key component of ruffed grouse diet and cover. Limited research conducted in the Appalachian region suggested ruffed grouse ecology and thus potential management differ greatly between the core of the species range (i.e., the Great Lakes and southern Canada region) and the Appalachian Mountains due at least in part to the absence of aspen. Breeding bird survey data from the U.S. Fish and Wildlife Service show a significant decline in ruffed grouse population indices over the last 35 years in both the Ridge and Valley and Alleghany Plateau regions of the Appalachians. These declines coincide with those of other early-successional bird species, and may be in part a result of changes in forest age over the last 35 years.

The nutritional quality of ruffed grouse diet differs markedly between the core range and the Appalachian region. Throughout most of their range, ruffed grouse depend on aspen (i.e., buds, twigs, and catkins) to meet their nutritional requirements. In contrast, ruffed grouse diets in the Appalachian region consist of the leaves and seeds of herbaceous plants, acorns, buds of beech, birch, and cherry trees, and fruits of greenbrier, grape, and numerous other soft mast producers. Diets of grouse in the Appalachian region tend to be higher in tannin and phenol levels, these chemicals serve as potential toxins. Additionally, Appalachian diets tend to have lower protein levels than the diets of grouse in the northern United States and Canada. The poor nutritional quality of grouse diets in the Appalachian region may result in increased foraging time and predation risk, and decreased body condition, reproductive potential, and chick survival.

In recent years, there has been a growing concern among wildlife managers, researchers, and hunters about the effects of hunting on ruffed grouse populations. In the Appalachian region, managers and researchers have been particularly concerned about the potential effects of late-season harvest (e.g., January and February), where hunting seasons tend to be longer than in the northern United States and Canada and the majority of the harvest is thought to occur during the late-season. Despite these concerns, little research has directly investigated the effects of regulated sport harvest on ruffed grouse populations.

The Appalachian Cooperative Grouse Research Project (ACGRP) was a 6-year research effort initiated in spring of 1996 to investigate the decline of ruffed grouse in the Appalachian region. Primary cooperators included state natural resources agencies in Kentucky, Maryland, Ohio, Virginia, West Virginia, Pennsylvania, Rhode Island, and North Carolina, and departments of wildlife sciences or biology at Eastern Kentucky University, Ohio State University, University of Tennessee, West Virginia University, California University of Pennsylvania, Fordham University, University of Rhode Island, and Virginia Tech. The cooperative nature of the project resulted in one of the largest ruffed grouse research projects ever conducted and provided insight into multiple aspects of ruffed grouse ecology and management in the Appalachian region.

Prior to the initiation of the ACGRP, ruffed grouse management in the Appalachian region was based on research conducted in the northern United States and Canada. Differences in grouse ecology and longer hunting seasons in the Appalachians require management based on research specific to the region. The goal of the ACGRP was to investigate ruffed grouse ecology and provide information necessary for the successful management of the region's ruffed grouse populations. The objectives of the ACGRP were to:

1. estimate survival rates and identify limiting factors,
2. estimate reproductive rates and identify limiting factors,
3. determine if harvest mortality is compensatory or additive,
4. evaluate habitat selection and quality.

STUDY AREAS AND FIELD METHODS

We studied ruffed grouse populations on 12 sites in 8 states throughout the Appalachian region (Table 1, Fig. 1). Landownership varied across sites and included National Forest Land, state public land, and industrial land owned by MeadWestvaco Corporation. Study sites range in size from 2,000–11,000 ha. The proportion of forest age classes (sapling, pole, and sawtimber) varied across sites due to differences in past timber management activities. Timber management activities ranged from no active harvest to selective harvest and clearcutting. MeadWestvaco lands had the most active timber harvesting programs and thus the greatest proportion of sapling age stands. Hunting seasons typically ran from early October to late February with daily bag limits ranging from 1–4 grouse and possession limits of 4–8.

Study sites (except OH1 and OH2) were classified as either oak-hickory or mixed-mesophytic forest associations based on literature review, canopy tree composition, and abundance data collected as part of the ACGRP (J.

Table 1. Description of study sites participating in the Appalachian Cooperative Grouse Research Project, 1996–2002.

Study Area	Ownership	Counties	RPI[a]	Forest Type	Hunting Treatment[b]	Years
KY1	State	Lawrence	8.21	Oak-Hickory	Closed	1996–2002
MD1	State	Garrett	33.62	Mixed-Mesophytic	Open	1996–2002
NC1	Federal	Macon	32.4	Mixed-Mesophytic	N / A	1999–2002
OH1	State, Private	Athens, Vinton, Meigs	N / A	N / A	N / A	1996–1999
OH2	State, Private	Coshocton	N / A	N / A	N / A	1996–1999
PA1	State	Clearfield, Elk	35.96	Mixed-Mesophytic	N / A	1998–2002
RI1	State	Kent	25.54	Oak-Hickory	N / A	1999–2002
VA1	Federal	Augusta	25.0	Oak-Hickory	Open	1997–2002
VA2	MeadWestvaco	Botetourt	27.81	Oak-Hickory	Open	1996–2002
VA3	State	Smyth, Washington	33.13	Mixed-Mesophytic	Closed	1996–2002
WV1	MeadWestvaco	Randolph	34.73	Mixed-Mesophytic	Open	1996–2002
WV2	MeadWestvaco	Greenbrier	28.15	Oak-Hickory	Closed	1996–2002

[a]RPI = relative phenology index
[b]Hunting treatment refers to hunting experiment during last 3 years of project.

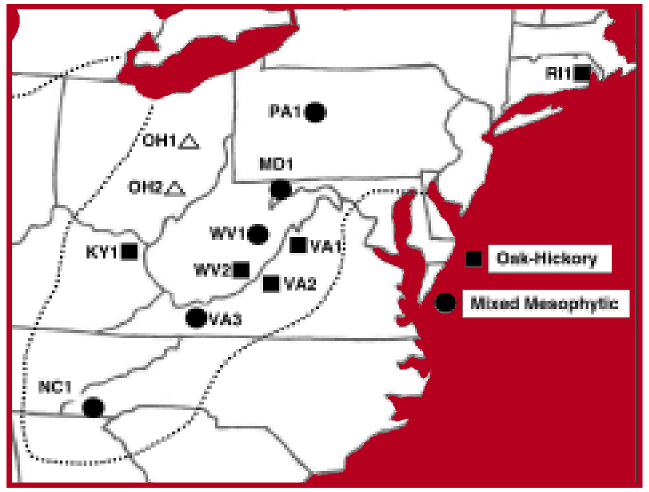

Figure 1. Location of Appalachian Cooperative Grouse Research Project study sites, 1996–2002. The dotted line indicates the distribution of ruffed grouse in eastern North America.

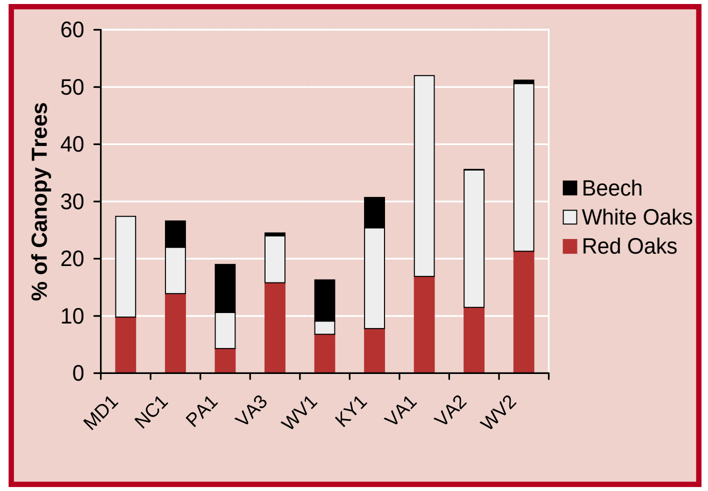

Figure 2. Percentage of canopy trees on ACGRP study sites represented by members of the red and white oak groups and American beech trees. Data were collected at randomly located 0.04ha plots (J. Tirpak, Fordham University, unpublished data; D. Whitaker, Virginia Tech, unpublished data). Sample sizes varied across sites: MD1 (n = 5,050 trees), NC1 (n = 5,587 trees), PA1 (n = 5,616 trees), VA3 (n = 7,259 trees), WV1 (n = 5,429 trees), KY1 (n = 3,825 trees), VA1 (n = 4,007 trees), VA2 (n = 6,142 trees), and WV2 (n = 7,804 trees).

Tirpak, Fordham University, unpublished data) and a Relative Phenology Index (RPI, Table 1). Oak-hickory forests were dominated by chestnut, white, northern red, scarlet and black oaks and shagbark, pignut, mockernut, and bitternut hickories. Other important tree species were red, sugar and striped maple; beech; table mountain, white, Virginia and pitch pine; and eastern hemlock. Mountain laurel and great rhododendron were important understory species. Dominant canopy species on mixed-mesophytic sites were sugar maple, red maple, yellow birch, basswood, black and pin cherry, yellow poplar, white pine, beech, northern red oak, and eastern hemlock. Other important species were white ash, white oak, and aspen. Hard mast producing species, including members of the red and white oak groups and beech were present on mixed-mesophytic and oak-hickory forests, but more abundant on oak-hickory sites (Fig. 2). Aspen, birch, and cherry were more abundant on mixed-mesophytic sites than on oak-hickory

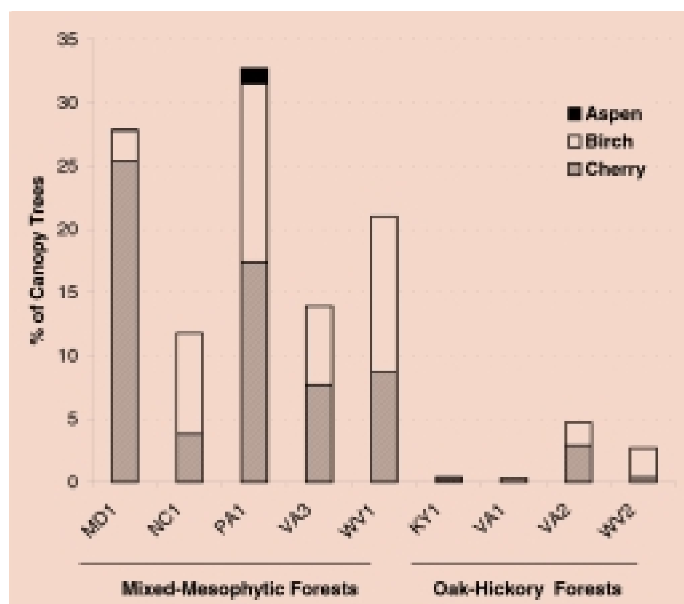

Figure 3. Percentage of canopy trees on ACGRP study sites represented aspen, birch, and cherry trees. Data were collected at randomly located 0.04ha plots (J. Tirpak, Fordham University, unpublished data; D. Whitaker, Virginia Tech, unpublished data). Sample sizes varied across sites: MD1 (n = 5,050 trees), NC1 (n = 5,587 trees), PA1 (n = 5,616 trees), VA3 (n,=,7,259 trees), WV1 (n = 5,429 trees), KY1 (n,= 3,825 trees), VA1 (n = 4,007 trees), VA2 (n = 6,142 trees), and WV2 (n = 7,804 trees).

sites (Fig. 3).

ACGRP personnel (here after "we") trapped ruffed grouse from August to December (fall) and February to April (spring) between 1996 and 2002 in lily-pad traps. We recorded the weight of each bird and determined age and gender based on feather characteristics. Birds were fitted with a uniquely numbered, aluminum leg band and a 10-g necklace style radio transmitter with an 8-hour motion detector then released at the capture site. After a 7-day acclimation period ruffed grouse were monitored ≥2 times per week to determine status (alive or dead), reproductive effort, and habitat selection.

We captured 3,118 ruffed grouse between fall 1996 and spring 2002 including 413 recaptures. The mean trap rate was 2.37 grouse/100 trap nights (Table 2). Trap success was greater for traps set near forest stand edges compared to traps set in mature forest stands. The ratio of juvenile grouse to adult females was 0.56 : 1.0 (Table 3). The sex ratio was slightly skewed and average 57% male (Table 4).

Table 2. Summary of ruffed grouse fall trap success in the central Appalachian region by study site, 1996–2002.

	Grouse/100 Trap nights				Flushes/100 Trap nights			
Study Area	***n***	**Mean**	**SE**	**95% CI**	***n***	**Mean**	**SE**	**95% CI**
KY1	6	1.41	0.314	0.60 – 2.21	6	0.60	0.215	0.05 – 1.15
MD1	5	2.17	0.482	0.83 – 3.51	5	1.81	0.454	0.55 – 3.07
NC1	3	0.89	0.135	0.31 – 1.47	.	.	.	.
OH1	1	3.20	.	.	1	1.03	.	.
OH2	2	4.59	0.930	0.0 – 16.41	2	1.66	1.050	0.0 – 15.00
PA1	4	6.00	1.23	2.06 – 9.92	4	1.98	0.201	1.34 – 2.62
RI1	3	1.23	0.289	0.0 – 2.48	3	0.51	0.182	0.00 – 1.29
VA1	5	0.87	0.168	0.41 – 1.34	5	2.22	0.384	1.16 – 3.29
VA2	6	1.06	0.322	0.23 – 1.88	6	1.27	0.236	0.66 – 1.88
VA3	6	1.13	0.065	0.96 – 1.29	6	0.35	0.087	0.13 – 0.58
WV1	6	3.00	0.391	2.00 – 4.00	6	2.13	0.481	0.90 – 3.37
WV2	6	4.71	0.551	3.29 – 6.13		.	.	. .

Table 3. Summary of fall ruffed grouse age ratios in the central Appalachian region by study site, 1996–2001.

	Juvenile : Adult Female				Juvenile Female : Adult Female			
Study Area	***n***	**Mean**	**SE**	**95% CI**	***n***	**Mean**	**SE**	**95% CI**
KY1	6	0.53	0.127	0.21 – 0.86	6	0.30	0.084	0.09 – 0.52
MD1	6	1.31	0.592	0.00 – 2.83	6	0.70	0.345	0.00 – 1.59
NC1	3	0.53	0.174	0.00 – 1.28	3	0.32	0.115	0.00 – 0.81
OH1	3	0.45	0.164	0.00 – 1.15	3	0.27	0.120	0.00 – 0.79
OH2	4	0.36	0.110	0.02 – 0.71	4	0.19	0.058	0.00 – 0.37
PA1	4	0.74	0.137	0.31 – 1.18	4	0.38	0.069	0.16 – 0.60
RI1	3	0.47	0.168	0.00 – 1.19	3	0.18	0.111	0.00 – 0.66
VA1	5	1.03	0.336	0.10 – 1.97	5	0.44	0.197	0.00 – 0.99
VA2	6	0.24	0.074	0.05 – 0.43	6	0.13	0.044	0.02 – 0.24
VA3	6	0.28	0.064	0.11 – 0.44	6	0.17	0.030	0.09 - 0.24
WV1	6	0.32	0.074	0.12 – 0.51	6	0.12	0.039	0.02 – 0.22
WV2	6	0.42	0.104	0.15 – 0.68	6	0.15	0.052	0.02 – 0.29

Table 4. Summary of fall ruffed grouse sex ratios in the central Appalachian region by study site, 1996–2001.

		Male : Female		
Study Area	***n***	**Mean**	**SE**	**95% C I**
KY1	6	1.77	0.398	0.99 – 2.55
MD1	6	1.19	0.224	0.75 – 1.63
NC1	3	1.04	0.206	0.64 – 1.45
OH1	3	1.44	0.366	0.72 – 2.15
OH2	4	1.32	0.129	1.06 – 1.57
PA1	4	1.25	0.232	0.79 – 1.70
RI1	3	2.66	0.547	1.59 – 3.74
VA1	5	1.76	0.586	0.61 – 2.91
VA2	6	1.22	0.154	0.92 – 1.52
VA3	6	1.32	0.225	0.88 – 1.77
WV1	6	1.70	0.182	1.35 – 2.06
WV2	6	2.14	0.744	0.68 – 3.59

FOOD HABITS AND NUTRITION

PRE-BREEDING FOOD HABITS OF RUFFED GROUSE IN THE APPALACHIAN REGION

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The food habits of ruffed grouse have the potential to affect behavior, movements, home range, survival, and reproduction and thus have gained a great deal of attention from researchers. Many studies have examined food habits during the fall and winter,

when hunter-killed specimens are readily available and have documented the diverse diet of ruffed grouse in the fall and winter. These studies examine ruffed grouse food habits when foods are abundant and widely distributed. Late-winter and early-spring food habit information is less available, and few studies have investigated food use during the time when resources are limited. Some researchers have hypothesized that the late-winter and early-spring diet of ruffed grouse in the Appalachians may be deficient, limiting densities in the region.

We analyzed 401 crops to quantify the diet of ruffed grouse approximately 2–3 weeks before the initiation of egg-laying in the Appalachians and Lake States. We obtained 326 crops from birds collected on 8 ACGRP study sites (KY1, MD1, NC1, PA1, VA1, VA2, WV1, and WV2) in March and April 2000–2002 and 75 crops were analyzed from grouse collected in Michigan, Wisconsin, and Minnesota during the same time period. We separated individual crop contents into 11 forage classes and then developed an Importance Value (IV = [aggregate % mass / 100 + % occurrence / 100] / 2) to assess the relative importance of forage classes and individual foods on a scale of 0 to 1.

Pre-breeding diets of ruffed grouse inhabiting oak-hickory and mixed mesophytic forests in the Appalachians differ markedly from diets of Lake State grouse found primarily in aspen or aspen-conifer forests. Ruffed grouse collected in Michigan, Wisconsin, and Minnesota relied heavily upon aspen flower buds, which made up 46% of the crop contents (Fig. 4) and had an importance value of 0.38 (Table 5). Aspen flower buds were found in only 7 Appalachian grouse and all were collected in Pennsylvania in 2000. The PA study site was the only site that had a significant aspen component in the forest (Fig. 3). Buds, twigs, and catkins of northern hardwood trees and shrubs also were important forages in the northern region.

Herbaceous leaves and flowers such as strawberry and cinquefoil were consumed regularly and occurred in 80% of the crops of north-

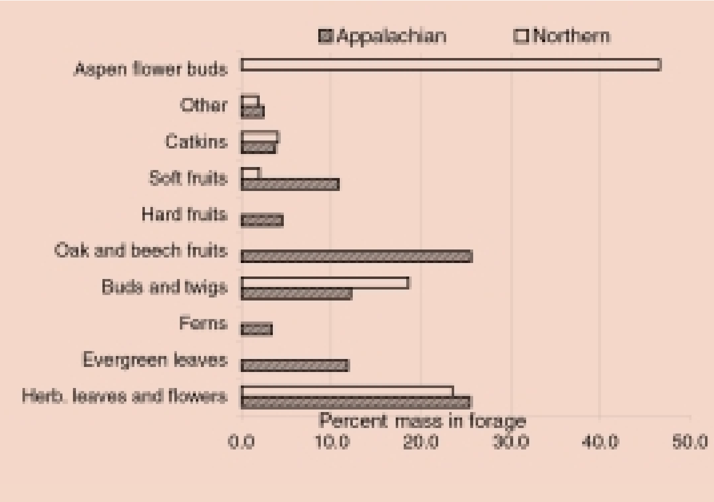


Figure 4. Percent mass of forage classes found in crop contents of Northern and Appalachian grouse collected in March-April 2000–2002.

ern grouse. Herbaceous leaf and flower use was similar in the Appalachians and accounted for 25% of total crop contents (Fig. 4). Consumption of herbaceous leaves and flowers may be related to spring green-up and the availability of other forages. On some sites, herbaceous leaf consumption varied significantly from year to year, most likely representing variations in the timing of spring green-up. Even when herbaceous plants are present, grouse may have selected other more preferred foods such as acorns. The overall importance of herbaceous leaves and flowers in the pre-breeding diet of Appalachian ruffed grouse is evident. Recently emerging leaves and flowers of species such as cinquefoil, strawberry, and coltsfoot are typically a readily available source of protein for pre-breeding hens and may contribute to the dietary needs of grouse in the weeks immediately preceding egg-laying.

Perhaps the most notable finding was the importance of oak and beech mast in the pre-breeding diet of Appalachian grouse. These hard fruits comprised the largest percentage of crop contents in the region (26%) despite being found in only 17% of the crops, suggesting acorns and beechnuts are consumed in large quantities when found. However, mast production patterns of oak and beech species are highly variable and do not provide a reliable food source. Acorns and beechnuts are among the most energy-rich forages available for grouse and appear to be highly selected for when available. The effects of mast production variability are difficult to assess, but may influence foraging times, predation, home range size, survival, body condition, and subsequent reproduction. Other hard fruits, such as maple samaras and witch-hazel seeds were relatively unimportant and accounted for a total of 5% of crop contents (Table 5).

Evergreen leaves, thought to be the poorest quality types of forage, were consumed regularly in the Appalachians, occurring in 36% of crops and accounting for 12% of the crop contents. Our analysis suggested that mountain laurel was often consumed when acorns were not eaten. Previous research has shown that ruffed grouse can maintain body mass with diets containing <20% evergreen leaves, but grouse consuming >40% evergreen matter will be unable to maintain body mass. We found 30 of 326 Appalachian crops with more than 40% evergreen leaves and 13 crops contained greater than 75% evergreen leaves. Whether or not these grouse had access to other higher quality foods is unknown, but if not, excess consumption of secondary toxic compounds present in evergreen leaves may be affecting as many as 10% of Appalachian grouse.

Table 5. Mean Importance Values [IV= (aggregate % mass / 100 + % occurrence / 100) / 2] of forages from crops of ruffed grouse collected in March and April, 2000–2002 in Michigan, Wisconsin, and Minnesota (North) and 8 study sites in the central Appalachians. Only forages with IV > 0.05 in at least 1 year are presented. Abbreviations are l. = leaves, fl. = flowers, c. = catkins, bt. = buds and twigs, fr. = fruit.

					SITE				
Forage	**North**	**PA**	**MD**	**WV1**	**WV2**	**VA1**	**VA3**	**KY**	**NC**
Alder c.	0.05								
Animal matter	0.10	0.06	0.05		0.04			0.02	0.02
Aspen fl.	0.38	0.10							
Avens l.	0.10	0.14	0.15			0.04		0.03	0.04
Azalea l.									0.02
Beech fr.		0.02		0.05				0.31	
Birdsfoot-trefoil l.		0.20			0.05		0.03		
Black birch bt.	0.04	0.07	0.11	0.05		0.02			0.06
Black birch c.		0.10	0.03	0.07		0.03			0.05
Blueberry / huckleberry bt.		0.22		0.04	0.19	0.09	0.11		0.07
Cherry bt.		0.04		0.02					
Cherry fr.			0.06						
Christmas fern l.			0.14	0.06	0.06	0.14	0.21	0.11	0.20
Cinquefoil l.	0.07	0.15	0.21	0.13	0.32	0.18	0.24		0.19
Clover l.	0.02			0.15	0.07	0.05	0.13		0.18
Coltsfoot fl.		0.16	0.03	0.06	0.07	0.12	0.23		
Dewberry l.		0.04		0.10		0.02			
Grape fr.		0.02							
Greenbrier fr.		0.02		0.11	0.08	0.07	0.04		0.07
Greenbrier l.				0.06	0.05	0.12	0.04	0.08	0.08
Hawkweed l.		0.04		0.14	0.14	0.06			0.05
Hornbeam c.	0.02					0.03			
Maple fr.		0.05	0.06		0.16	0.02	0.04		
Mountain laurel bt.				0.10	0.09	0.04	0.04		0.02
Mountain laurel l.		0.05		0.23	0.23	0.16	0.14		0.23
Multiflora rosa l.				0.06		0.03		0.10	0.03
Oak fr.		0.22	0.10	0.04	0.27	0.19	0.35		0.09
Pyrola spp. l.	0.12								
Ragwort l.							0.04	0.03	0.04
Serviceberry bt.		0.08	0.03	0.03	0.02	0.09	0.07		0.06
Sorrel l.			0.05						0.05
Strawberry l.	0.25		0.07				0.02		0.09
Sumac fr.		0.12	0.02					0.03	
Trailing arbutus l.		0.04			0.04	0.06	0.03		0.02
Viburnum spp. fr.						0.04			
Wintergreen fr.		0.03		0.06	0.05	0.07			
Wintergreen l.	0.02	0.03							
Witchhazel bt.				0.02	0.02	0.04			
Witch-hazel fr.			0.02	0.16	0.03				
Wood fern l.	0.07	0.23	0.15		0.04	0.04	0.02	0.07	
Yellow Birch c.			0.05						

Also, during late winter when herbaceous leaves were likely unavailable, evergreen leaf consumption may have been significantly higher than we detected, giving further credence to the hypothess theory that high-quality winter foods may be lacking in this region.

Soft mast was a moderately used forage class in the Appalachians and composed 11% of all crop contents in the region, although its abundance and distribution was variable among and within sites and years. Fruits of grape and greenbrier were the most common species found in this category, but other fruits such as sumac and cherry were also consumed. Buds and twigs were found in 47% of Appalachian crops but comprised only 12% of crop contents. Birch, cherry, serviceberry, blueberry, and huckleberry were among the most common species of buds eaten (Table 5). Buds and twigs are low-energy, high fiber food sources that are readily available when other more preferred species are not present. Other food classes, such as catkins, ferns, and animal matter were relatively unimportant components of the pre-breeding diet of grouse in the region.

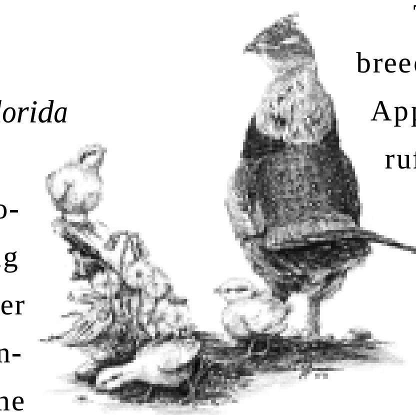
Overall, we found the pre-breeding food habits of Appalachian grouse to be substantially different from food habits of grouse inhabiting aspen-dominated forests in the Lake States. Because grouse densities reach their highest levels in aspen dominated forests, we can assume that the northern diet is adequate to meet their dietary and reproductive needs. However, the same cannot be said for grouse in Appalachia. We found pre-breeding diets to be highly variable among and within ACGRP study sites. When food habits data are summarized at a site level, it appears that the composite diet would be nutritionally adequate, but the results fail to capture the diets of individual grouse, which undoubtedly are more important than the "average" diet of the study site. We believe that pre-breeding diets of Appalachian ruffed grouse are strongly influenced by the cover types present in the home range of individual grouse and by annual patterns of mast production at the local level. Furthermore, the distribution of food sources between habitat types and among years may be an important determinant of grouse densities in the Appalachians.

Bob Long worked with the ACGRP from 1999–2002 conducting fieldwork on the Pennsylvania study site and researching ruffed grouse nutrition and condition. He holds a B.S. in Wildlife Science from Virginia Tech and is working towards a M.S. from West Virginia University. He is currently the Wild Turkey and Upland Game Bird Project Manager for the Maryland Department of Natural Resources.

FOOD HABITS AND NUTRITION

PRE-BREEDING NUTRITIONAL CONDITION AND POTENTIAL EFFECTS ON REPRODUCTION

by: Bob Long and John Edwards,
West Virginia University, and
William Giuliano, University of Florida



Poor pre-breeding physiological condition resulting from an inadequate winter diet has been hypothesized to contribute to low grouse densities in the Appalachians. Previous research shows that leaves of evergreen plants, fruits, and ferns compose the majority of the winter diet of grouse in the Appalachians, whereas grouse in the northern United States and Canada forage primarily on buds, twigs, and catkins of aspen and other northern hardwood tree species. When available, soft and hard mast is used extensively during the fall and winter months in the Appalachians, but significant annual and regional variations in mast production may limit its ability to sustain grouse through the winter. Winter evergreen forages used by grouse in the Appalachians have lower energy and protein levels than buds and catkins and contain toxic secondary compounds that may inhibit digestion. Poor quality late-winter diets in the Appalachians may adversely affect the physiological condition of breeding females and decrease reproductive success. The low chick survival and recruitment observed in the Appalachians may in part result from the poor condition of females entering the breeding season.

To better understand the role of pre-breeding nutritional condition in Appalachian grouse, we collected 352 ruffed grouse from 8 ACGRP sites in March and April 2000–2002 approximately 2–3 weeks prior to the egg-laying period. Additionally, we collected 80 grouse during the same time period in Michigan, Wisconsin, and Minnesota to compare the pre-breeding condition of ruffed grouse in the core range. We determined percent carcass fat, which is generally considered the most accurate index of nutritional condition. We then developed mathematical models to assess the effect of female condition on productivity.

Individual grouse carcass fat levels ranged from 1.3% to 39.7% with a mean of 9.9% and were highly variable both among and within sites and years and between sexes (Table 6). Female grouse consistently had greater percent carcass fat than did males (12.5 vs. 7.4%). This may be the result of male grouse spending less time foraging and more time with breeding activities as spring approaches. Grouse collected in the northern Lake States had lower fat levels (6.0%) than Appalachian grouse (10.8%).

To investigate the relationship between the pre-breeding diet and condition of ruffed grouse in the Appalachians, we conducted 3 separate analyses. First, we assessed 29 *a priori* models using food habits variables we hypothesized may

Table 6. Percent carcass fat of ruffed grouse collected March-April 2000–2002 at 8 sites in the central Appalachians and in Michigan, Wisconsin, and Minnesota.

Site	Year								
	2000			2001			2002		
Sex	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE
KY									
Female	3	11.2	1.6	2	28.3	4.3	6	11.7	1.5
Male	1	5.1	.	5	16.4	1.0	10	8.8	1.4
Combined	4	8.2	2.9	7	22.3	2.1	16	10.2	1.3
MD									
Female	7	12.9	2.5	7	8.0	1.6	5	25.9	2.6
Male	12	7.0	0.9	3	7.7	2.1	2	15.9	4.2
Combined	19	9.9	1.2	10	7.9	1.8	7	20.9	2.1
NC									
Female	8	5.6	1.0	9	11.7	2.2	7	8.8	1.3
Male	12	5.2	0.5	11	7.3	0.7	10	7.7	1.4
Combined	20	5.4	1.2	20	9.5	1.1	17	8.2	1.3
PA									
Female	8	15.1	2.7	7	8.6	2.1	8	16.2	2.9
Male	11	5.6	0.5	8	9.7	2.3	6	10.0	2.5
Combined	19	10.3	1.2	15	9.1	1.3	14	13.1	1.4
VA1									
Female	11	25.0	2.4	8	14.6	1.9	8	13.2	3.5
Male	5	9.8	1.6	16	10.5	1.0	9	6.9	0.6
Combined	16	17.5	1.4	24	12.5	1.1	17	10.0	1.3
VA3									
Female	12	15.6	2.4	6	10.1	1.8	8	27.0	1.0
Male	10	7.1	1.1	8	6.9	1.1	5	19.0	2.5
Combined	22	11.3	1.1	14	8.5	1.4	13	23.0	1.5
WV1									
Female	6	7.8	1.6	6	8.8	0.6	10	10.4	1.6
Male	8	5.1	0.7	2	14.6	8.0	7	6.9	1.7
Combined	14	6.4	1.4	8	11.7	2.1	17	8.6	1.3
WV2									
Female	5	12.0	3.0	7	7.2	0.9	6	14.0	4.4
Male	8	7.2	1.3	4	6.6	0.7	9	4.1	0.4
Combined	13	9.6	1.5	11	6.9	1.6	15	9.0	1.3
Northern States									
Female	16	7.9	0.9	15	6.7	1.0	5	7.3	3.0
Male	16	5.6	0.7	18	4.2	0.4	10	4.7	0.4
Combined	32	6.7	0.6	33	5.4	0.5	15	5.6	1.0

explain variation in carcass fat levels. We summarized food habits data and used food class Importance Values (IVs; see food habits section for description) as the explanatory variables to investigate variation in the mean percent carcass fat for each site / sex / year combination. Our data demonstrated a negative relationship between evergreen leaf and bud / twig consumption and fat levels and a positive relationship between oak and beech fruit, catkin, and fern consumption and fat levels. In our second analysis, we discovered a relationship between an index to mast availability and mean fat levels. We then assumed the presence or absence of acorns or beechnuts in the crop at the time of collection may reflect whether a grouse had access to hard mast throughout the winter period, which would increase the nutritional fitness of that bird. A third modeling analysis indicated the presence or absence of mast in the crops was an important determinant of fat levels. Females collected with mast in the crop contained 20% carcass fat, whereas females collected without mast in the crop only had 11.7% carcass fat (Fig. 5). A similar difference was found in males.

Our hypothesis that high acorn intake may increase fat reserves was supported by our findings. Acorns are a highly digestible source of energy and when abundant can satisfy the dietary needs of grouse with minimal foraging times which may also decrease exposure to predators. However, oak is not a major component of some Appalachian forests, and even when present, mast production is variable. When hard mast is not available, grouse forage more on less energy-rich foods such as buds, twigs, ferns, and evergreen leaves, which were negatively related to fat reserves.

Reproductive data were gathered at each site and we compared mean fat levels of female grouse to reproductive parameters for each site / year combination. Clutch size, hatching success and nest success all were positively related to percent carcass fat. Chick survival to 5 weeks also was positively related to the amount of carcass fat in

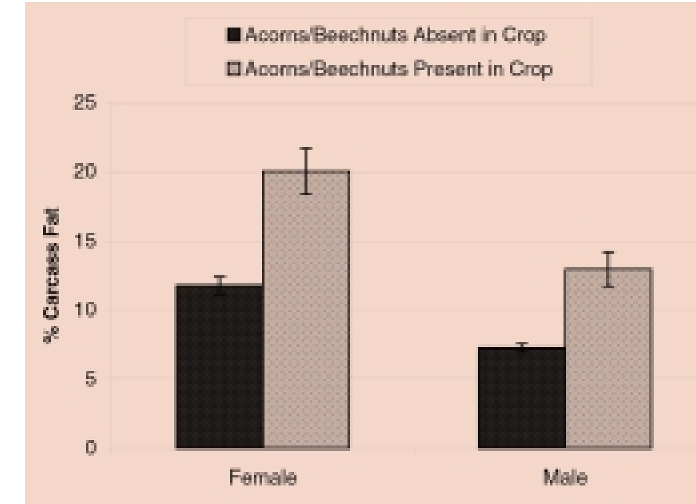


Figure 5. Percent fat of Appalachian grouse collected with and without acorns or beechnuts in crop during early spring, 2000–2001. Vertical bars represent the 95% confidence interval on the estimate.

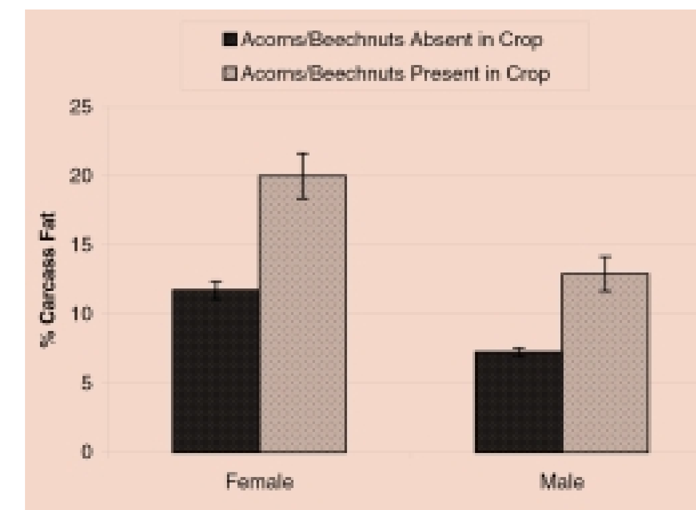


Figure 6. Ruffed grouse chick survival on study sites in the Appalachian region with low, moderate, and high levels of carcass fat. Vertical bars represent the 95% confidence interval on the estimate.

females, as was an index of recruitment. Sites with low mean fat levels had low chick survival rates at 5 weeks post-hatch (0.13) compared to sites with moderate (0.37) and high (0.26) fat levels (Fig. 6). Sites with moderate or high carcass fat levels had higher Recruitment Index values (2.87 and 2.09, respectively) than sites with low fat levels (1.17).

Our data suggest that reproductive success in the Appalachians is strongly influenced by several factors. The importance of site in many of our models suggests that some component of each individual site (e.g., habitat, predators, weather, etc.) has an effect on reproduction. Year-to-year variation may reflect regional weather patterns that impacted reproduction. Fat levels were positively related to nearly every aspect of reproduction that we measured. However, pre-breeding condition appears to be most influential on chick survival, particularly chick survival in the first few weeks after hatching. Our data suggest that survival and recruitment may be highest when grouse are in an "average" state of nutritional condition (approx 11–15% carcass fat), and that productivity may actually decline when grouse retain large amounts of body fat. Ruffed grouse with abnormally large fat reserves may have been feeding exclusively on high-energy, low-protein food sources such as acorns. Large amounts of both energy and protein are needed for reproduction and protein deficiencies may have resulted in lowered reproductive output. An alternate theory we suggest is that approximately 11% body fat represents a threshold level that is needed for successful reproduction in the Appalachians, and once that threshold is exceeded other factors become more influential than condition. Previous research supports the idea that nutritional deficiencies in laying hens can result in poorer quality eggs, low chick weights, and low chick survival in game birds. It should be noted that our analyses were limited to the site-level. The grouse we collected had to be sacrificed to obtain condition data, then the results compared to the reproductive success of other radio-tagged grouse in the same general area. We believe that if these coarse analyses detected such a pattern, an examination of the effects of condition at the bird-level may reveal an even stronger relationship and is surely worthy of additional research.

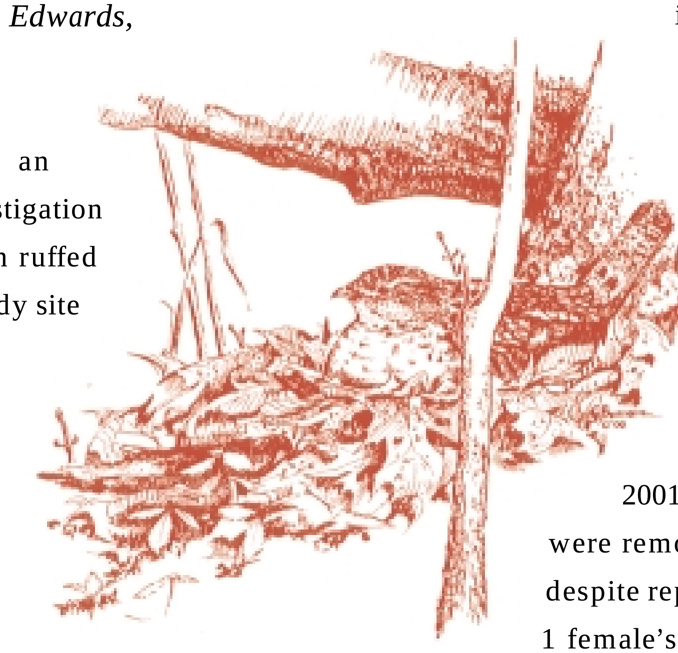
As a result of these findings the ACGRP has initiated further research on the effects of different nutritional diets (various energy and protein combinations) on reproduction. This study is being conducted on captive ruffed grouse at West Virginia University by Dr. John Edwards and Aaron Proctor.

Bob Long worked with the ACGRP from 1999-2002 conducting fieldwork on the Pennsylvania study site and researching ruffed grouse nutrition and condition. He holds a B.S. in Wildlife Science from Virginia Tech and is working towards a M.S. from West Virginia University. He is currently the Wild Turkey and Upland Game Bird Project Manager for the Maryland Department of Natural Resources.

NESTING AND REPRODUCTIVE OUTPUT

PREDATION OF RUFFED GROUSE NESTS IN WEST VIRGINIA

by Brian W. Smith and John Edwards,
West Virginia University



We conducted an intensive investigation of predation on ruffed grouse nests on the WV2 study site via miniature cameras. The objectives of this study were to identify nest predators and investigate factors that influence nest predation.

We monitored 10 nests in 1999, 11 nests in 2000 and 4 nests in 2001 and observed 23 nest visitors (9 species, 3 taxa) to 13 ruffed grouse nests. Only 5 of 23 nest visits resulted in egg depredation; a black bear, 2 raccoons, a black rat snake, and long-tailed weasel were responsible for the observed nest predations. We recorded the 3 nest depredation events in 2000; in all cases, the female escaped predation despite remaining on the nest until the predator nearly captured them. One additional nest depredation event occurred at a nest with a camera, but power to the camera failed overnight and the event was not captured on tape. However, a raccoon was observed at the nest that morning when we arrived to change the videotape; we assume the raccoon was responsible for the nest loss. In 1999, a long-tailed weasel attempted to capture the incubating hen on 2 different nights but was unsuccessful; the weasel did not destroy any eggs on either visit. We also observed eastern chipmunks at 2 different nests in 2001; however, no eggs were removed from either nest despite repeated visits ($n = 5$) to 1 female's nest. We observed a shrew at 1 nest shortly after the female left the nest with her brood. The shrew removed all eggshells from the nest bowl, presumably to consume liquids and / or shell fragments.

During the egg-laying period, neither the amount of time females spent on or off their nests, nor total number of times they turned their eggs per hour differed by age of hen, nest outcome, day in nesting cycle, or associated interactions. During incubation, we determined that the length of time that females stayed on nests during the day increased as incubation progressed and the length of time that females were off nests decreased as incubation progressed. We found no differences in several egg-turning behaviors, with the exception that nighttime egg-turning activity changed throughout the nesting cycle, with peaks in egg-turning activities during early and late incubation, and number of daytime egg turning events was influenced by female age. Females that lost their nest had a higher proportion of time on nests on the day of predation than all other days, but number of egg turning events per hour (total, daytime, or nighttime) did not differ. When compared to successful nests, hens that lost their nest had spent more time on nests on the day of predation than those that did not lose nests.

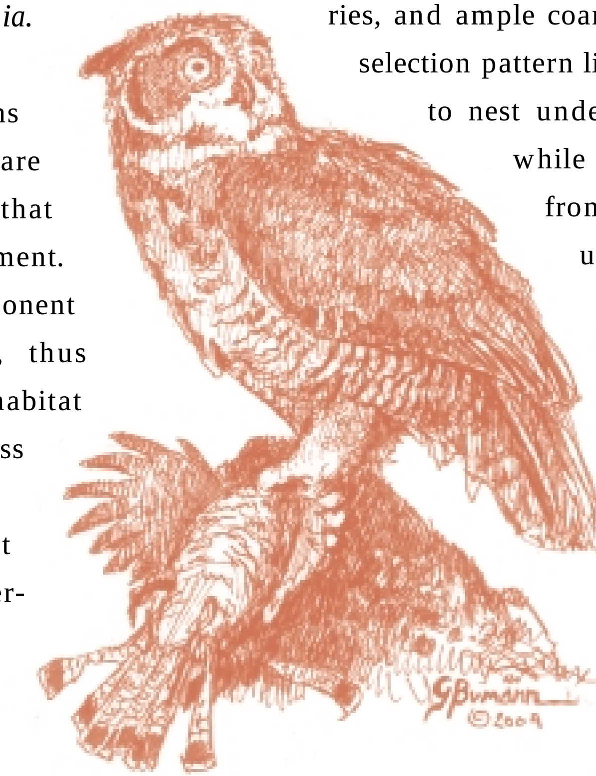
Nest predation may in be limiting grouse populations in the Appalachians, but it may also influence the evolution of their life-history traits. From this study, it appears that ruffed grouse nesting behaviors may have evolved in order to (1) reduce the probability of predation (i.e., infrequent trips to and from nests) and (2) maximize development rates of embryos (i.e., high nest attentiveness rates).

Brian W. Smith received a B.S. in Wildlife Management from Eastern Kentucky University in 1995 and an M.S. in Raptor Biology from Boise State University in 1999. He is currently the Wildlife Diversity Program Coordinator for Kentucky Department of Fish and Wildlife Resources, having recently transferred over as their Upland Game Program Coordinator. He is a Ph.D. candidate at West Virginia University, where his dissertation research focused on ruffed grouse nesting ecology, chick survival, and dispersal in the Appalachian Mountains.

NESTING AND REPRODUCTIVE OUTPUT

INFLUENCE OF NEST SITE SELECTION ON RUFFED GROUSE NEST SUCCESS IN THE APPALACHIANS

by John M. Tirpak and Bill Giuliano, California University, Pennsylvania.



Ruffed grouse populations in the Appalachians are experiencing declines that may be linked to poor recruitment. Nest success is an important component of ruffed grouse productivity, thus understanding the role microhabitat plays in determining nest success may be important for developing regional grouse management strategies. Therefore, we determined nest success (defined as the proportion of nesting hens that hatch ≥ 1 egg) rates, characterized nest site selection, and identified habitat characteristics associated with successful nests in the region. From 1996 through 2002, we collected habitat data at 234 known-fate nests on 8 study areas (KY1, MD1, PA1, VA1, VA2, VA3, WV1, and WV2) and at an additional 2,259 systematic points on the MD1, PA1, VA3, WV1 and WV2 sites. Nest success ranged from 52–87% for individual study areas and 58–78% for individual years. Overall, nest success averaged 63% (see reproductive section by P. Devers), a rate consistent with reports from other areas of ruffed grouse range. Females selected nest sites in sapling (<12.5 cm dbh) stands, near roads and openings (<30 m), and in areas with open canopies, dense herbaceous understories, and ample coarse woody debris. The selection pattern likely reflects the desire to nest under or adjacent to logs, while remaining concealed from predators in dense under-stories. Successful nests were more often located further (>100 m) from an opening, in pole (12.5–27.8 cm dbh) stands, and in understories with 21–60% woody and <30% herbaceous vegetation than unsuccessful nests. Alternatively, nests located near an opening, in sapling stands, and in open under-stories were more likely to be unsuccessful. Habitat characteristics associated with successful nesting did not parallel habitat selection patterns of females. Although nests located in dense under-stories were more likely to be successful, nests in sapling stands and near openings were more likely to fail. Because females selected dense herbaceous under-stories for nesting and realized higher nest success in these areas, we recommend partial over-story harvesting of pole and sawtimber stands to reduce basal area, open the mid-story and canopy, and increase the understory vegetation and coarse woody debris loads of these stands. Provided logging roads into these stands are seeded, they would likely have minimal impact on nest success of ruffed grouse and can provide important brood foraging sites. Group selection cuts in small patches (<0.25 ha) may effectively create and maintain secure nesting cover without creating large canopy gaps or extensive sapling stands in close proximity to nesting habitat. We caution that neither of these practices can create sufficient early-successional stands for ruffed grouse or area-sensitive disturbance-dependent species, and our recommendations are only appropriate when applied in conjunction with large scale (>0.25 ha) even-aged harvests or large group selection cuts. Because the Appalachian landscape is primarily forested, fragmentation effects due to timber harvest may be minimal, and the diversity of many forest-interior species can be maintained.

John M. Tirpak is currently a Ph.D. candidate in the Department of Biological Sciences at Fordham University. He has been involved with the ACGRP for the last 5 years, receiving an M.S. in Biology from California University of Pennsylvania while working on the PA/01 site. Prior to that, he received his B.S. in Wildlife Management from West Virginia University. His research focus is the influence of habitat on population dynamics of ruffed grouse.

NESTING AND REPRODUCTIVE OUTPUT

SURVIVAL AND CAUSE SPECIFIC MORTALITY OF RUFFED GROUSE CHICKS IN THE APPALACHIANS

by Brian W. Smith, Chris Dobony, and John Edwards, West Virginia University

Although survival estimates and mortality causes of adult ruffed grouse can be readily obtained via radio telemetry, transmitter size and lack of reliable attachment methods have limited examination of these parameters for ruffed grouse chicks. Because mortality in ruffed grouse is highest during the first few weeks of life, understanding the factors influencing chick survival is important for their management. Many studies have addressed survival of subadult and adult ruffed grouse, but factors that influence chick survival have not been well documented. Arthropod abundance and availability, inclement weather, and predation influence chick survival, but to what extent each factor plays in the Appalachian Mountains is uncertain. Also, complete brood loss within a few days post-hatch appears more common in the Appalachians than in the northern portion of ruffed grouse distribution.

Therefore, we attached collar-type transmitters to ≤3-day-old grouse chicks to monitor survival and cause-specific mortality in the Appalachian Mountains. Specifically, we determined rates of exposure deaths, predation rates by various types of predators, other forms of mortality in ruffed grouse chicks, and survival to 5-weeks post-hatch at 3 study sites (PA1, VA2, and WV1).

From 2000 through 2002 we captured 177 chicks from 50 broods and equipped 139 of these chicks with transmitters (62 chicks on WV1, 40 on PA1, and 37 on VA2). Ruffed grouse chicks selected to receive radio transmitters had a mean weight of 14.7 g (when captured at 2–4 days post-hatch). We determined fates of 118 (85%) of the 139 radio-collared chicks, with 110 (79%) succumbing to some form of mortality and 8 (6%) surviving to 35-days post-hatch (Table 7). All chicks marked with necklace-type transmitters retained their transmitters until death or throughout the 35-day post-hatch sampling period, upon which they were captured and their transmitters removed. Exposure (44%) and predation (44%) were the leading causes of chick mortality, and were likely underestimates given the number of individuals with which we lost contact. The percent of mortalities that were mammalian (38%) and avian (33%) was similar. We lost contact with 15% (21 of 139) of the collared chicks; we were unable to determine if the transmitters failed or if the chicks were depredated. Therefore, predation rates and type of predator represent minimum estimates. Of the 118 chicks with known fates, 8 (6%) survived to 35-days post-hatch and had their collars removed. Overall, survival of ruffed grouse chicks was extremely low and cause of mortality varied by age and year.

Brian W. Smith received a B.S. in Wildlife Management from Eastern Kentucky University in 1995 and an M.S. in Raptor Biology from Boise State University in 1999. He is currently the Wildlife Diversity Program Coordinator for Kentucky Department of Fish and Wildlife Resources, having recently transferred over as their Upland Game Program Coordinator. He is a Ph.D. candidate at West Virginia University, where his dissertation research focused on ruffed grouse nesting ecology, chick survival, and dispersal in the Appalachian Mountains.

Chris Dobony is currently a Fish and Wildlife Biologist on Fort Drum Military Installation in Fort Drum, New York. He makes up one half of the Fish and Wildlife Management Program at Fort Drum, and assists in the management of all natural resources, with specific focus on baseline species surveys and deer and beaver management. He received his B.S. in Environmental Forest Biology from the SUNY College of Environmental Science and Forestry (1997),and his M.S. in Wildlife and Fisheries Resources from West Virginia University (2000).

NESTING AND REPRODUCTIVE OUTPUT

RUFFED GROUSE REPRODUCTION AND PRODUCTIVITY IN THE APPALACHIAN REGION

by: Patrick K. Devers and Dean F. Stauffer, Virginia Tech

It has been long suspected that ruffed grouse in the Appalachian region have lower productivity and recruitment than grouse in the Lake States and southern Canada. To evaluate this we monitored 467 females during nest and brood seasons from 1997 through 2002 to estimate ruffed grouse productivity in the Appalachian region. Reproductive effort and success was greater on mixed-mesophytic forests than on oak-hickory forests (Table 7). Additional comparison of reproductive rates among oak-hickory and mixed-mesophytic forests and the core of the species range suggest oak-hickory forests provide low quality reproductive habitat, mixed-mesophytic forests provide intermediate quality reproductive habitat, and the northern hardwood forests provide the high quality reproductive habitat (Table7).

Nest rate (the proportion of females that attempt to nest) was lower on oak-hickory forests (86%) than on mixed-mesophytic forests (100%). Our estimates of nest rate on mixed-mesophytic forests were similar to rates reported in the Great Lake states and southern Canada. During the course of their study, Gardner Bump and his co-workers in New York reported 100% nest rate during 7 of 10 years, and suggested non-nesting females may be "physiologically upset and

Table 7. Comparison of reproductive parameters on oak-hickory and mixed-mesophytic forests in the central Appalachian region and northern hardwood forests of the Great Lakes region.

		Forest	
Parameter	**Oak-Hickory**	**Mixed-Mesophytic**	**Lake States**
Nest Rate	86%	100%	100%
Re-Nest Rate	3.2%	45%	>50%
Clutch Size	9.4 eggs	10.7 eggs	>11 eggs
Nest Success	63%	70%	>50%
Chick Survival	21%	39%	50%

unable to breed properly." Though they did not elaborate on what mechanism may cause females to by physiologically upset, several others have suggested that ruffed grouse in the Appalachians may be nutritionally stressed and enter the reproductive season in poor body condition (e.g., with lower lipid reserves) resulting in lower reproductive effort and success. The low nest rate of ruffed grouse on oak-forests forests compared to the high nest rate on mixed-mesophytic forests and northern hardwood forests suggests not all grouse in the Appalachians are nutritionally stressed, but rather only grouse inhabiting areas dominated by oak-hickory forests are nutritionally stressed.

Re-nest rate is defined as the proportion of females that lost their first nest and attempted to lay a second clutch. Research conducted in the Lake States reported re-nest rate of >50%. Our results indicate similar re-nest rates on Appalachian mixed-mesophytic forests (45%), but extremely low re-nest rate on oak-hickory forests (3.2%). Again, these results suggest female ruffed grouse on oak-hickory forests are nutritionally stressed and do not possess the required energy reserves (e.g., lipids and proteins) to lay a second clutch.

Nest success is defined as the proportion of females that hatched ≥1 chick in their first nest attempt. Nest success was lower on oak-hickory forests than on mixed-mesophytic forests, but similar to rates reported for the core of the species range (Table 8). The leading cause of nest loss was predation. Several species were documented as nest predators via miniature video cameras including raccoon, black snake, black bear, and long-tailed weasel (unpublished data B. Smith, West Virginia University).

Mean clutch size of first nests was lower on oak-hickory forests (9.4 eggs) than on mixed-mesophytic forests (10.7 eggs). Clutch size on mixed-

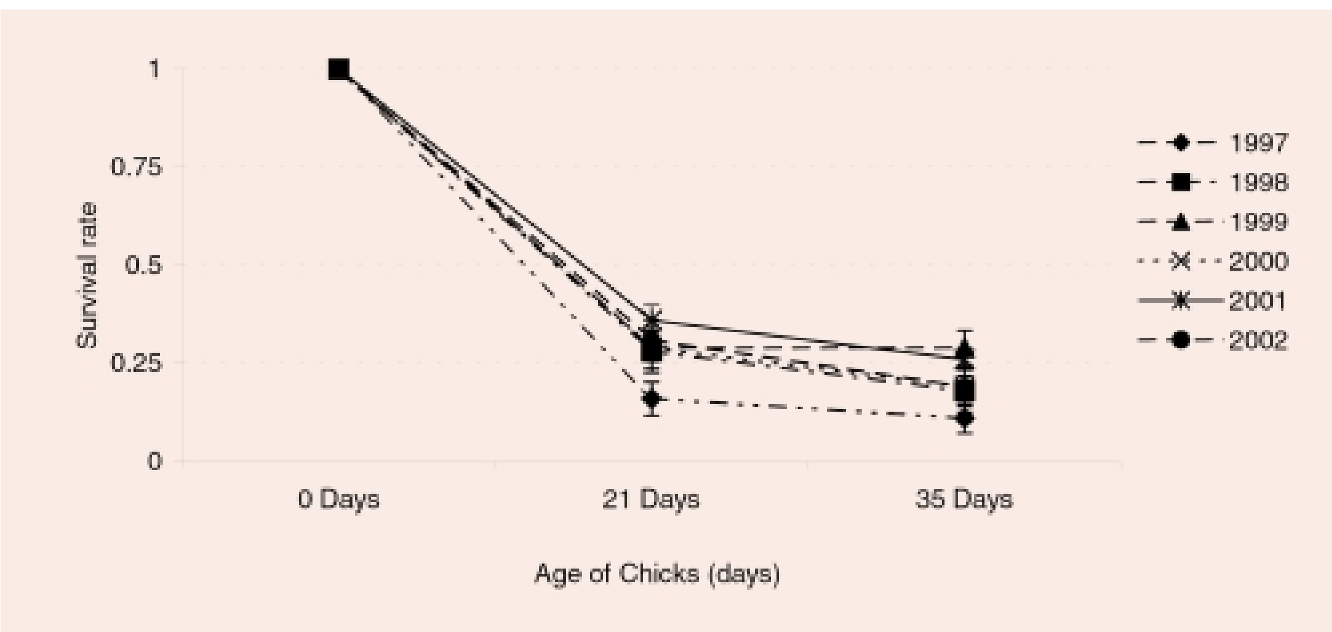


Figure 7. Ruffed grouse chick survival to 21- and 35-days post-hatch in the Appalachian region, 1997–2002. Vertical bars represent the 95% confidence interval on the estimate.

mesophytic forests was similar to clutch sizes reported in the core of ruffed grouse range (Table 7). Our finding of smaller mean clutch size on oak-hickory forests than on mixed-mesophytic forests further supports the contention that female grouse on oak-hickory forests may be nutritionally stressed and in poor body condition.

Biologists have suggested low chick survival is an important contributing factor to relatively low abundance of ruffed grouse in the Appalachian region. To assess this hypothesis we estimated chick survival to 35-days post-hatch. This was accomplished by first determining the brood size by counting the number of eggs that hatched and then flushing the female and counting the number of chicks alive at 21- and 35-days post-hatch. Chick survival in the Appalachian region was poor, averaging 22% to 35-days post-hatch (Fig. 7). Chick survival to 35-days post-hatch was higher on mixed-mesophytic forests (39%) than on oak-hickory forests (21%). In comparison, chick survival to 84 days (12 weeks) post-hatch in the Great Lakes region is ≥50%.

Chick survival was positively correlated with hard mast production the previous fall, providing additional evidence that ruffed grouse productivity and recruitment in the Appalachian region is strongly influenced by the quality and availability of food resources, especially hard mast. Food availability and quality is an important factor in successful reproduction in birds; he availability of high quality food improves female condition, egg quality, and chick survival. We suggest that in years with poor mast production females enter the reproductive season with fewer lipid and protein reserves and lay lower quality eggs (e.g., smaller yolks) which results in less robust chicks and lower survival to 35-days post-hatch.

Patrick Devers is a Ph.D. candidate at Virginia Tech studying ruffed grouse population ecology as part of the Appalachian Cooperative Grouse Research Project. He received his B.S. degree in wildlife biology from Colorado State University in 1997 and his M.S. in Renewable Natural Resources from the University of Arizona in 1999. Patrick will join the Conservation Management Institute at Virginia Tech after completing his degree in the fall of 2004. Pat's research interest include population ecology and monitoring, and the human dimensions of wildlife conservation.

SURVIVAL AND PREDATION

RUFFED GROUSE SURVIVAL
IN THE APPALACHIAN REGION

by: Patrick K. Devers and Dean F. Stauffer, Virginia Tech

Adult survival is a critical component of population growth and viability. The ACGRP was initiated due to the concern over the decline of ruffed grouse in the region. Researchers and managers in the region were particularly concerned with assessing survival and the effects of hunter harvest on population viability. To this end, the ACGRP was designed to experimentally test the compensatory mortality hypothesis. The ACGRP hunting experiment was conducted on 7 study sites (Table 1) during the 6-year study. The study was separated into two 3-year phases. During Phase I (1996–1998) each of the study sites was open to normal hunting seasons and regulations. Hunting seasons typically ran from early October to late February with daily bag limits ranging from 1–4 grouse and possession limits of 4–8 birds. During Phase II (1999–2001) the 3 treatment sites with the highest hunting mortality rates in Phase I (KY1, VA3, and WV2) were closed to hunting, while the 4 remaining control sites remained open to normal hunting seasons and regulations. This experimental design allowed researchers to evaluate whether regulated sport harvest caused a decrease in annual ruffed grouse survival.

The average annual survival rate of ruffed grouse in the Appalachian region was 43%, but varied across forests associations, years, and seasons. Annual survival rate was greater on oak-hickory forests (50%) than on mixed-mesophytic forests (39%). Survival was highest in summer and lowest in winter in both forest types, but again seasonal survival rates were higher on oak-hickory forests than on mixed-mesophytic forests (Fig. 8). Seasonal survival trends were similar to trends reported throughout ruffed grouse range. There was no evidence that survival differed between adults and juveniles or between males and females. The leading cause of grouse mortality was avian predation, followed by mammalian predation, and predation by unidentified predators (Fig. 9).

Survival of grouse in both treatment and control groups tended to increase in the Phase II of the project (Fig. 10). However, we did not find evidence of an interaction effect or larger than expected increase in the treatment group where hunting had been closed. Over the 6 years ruffed grouse annual survival did not differ between

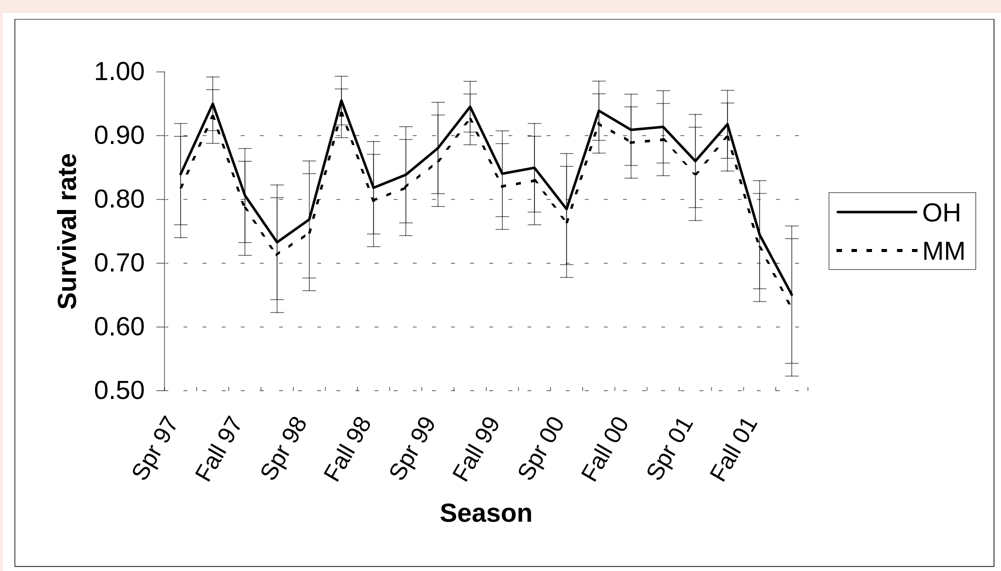


Figure 8. Ruffed grouse survival on oak-hickory and mixed-mesophytic forests in the Appalachian region, 1997–2002. Vertical bars represent the 95% confidence interval on the estimates.
OH = oak-hickory forests, MM = mixed mesphytic foests

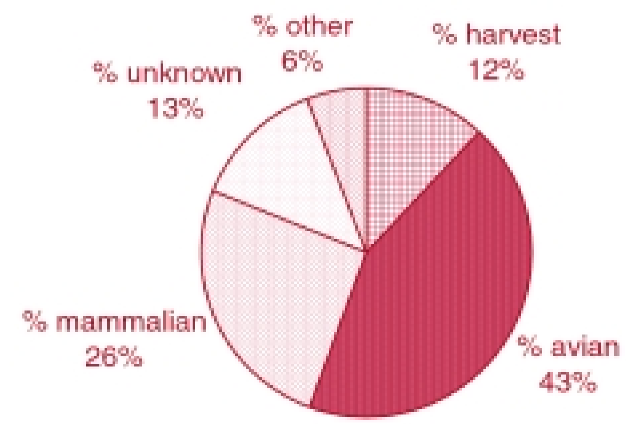


Figure 9. Percent of known ruffed grouse mortality by cause in the Appalachian region, 1997–2002.

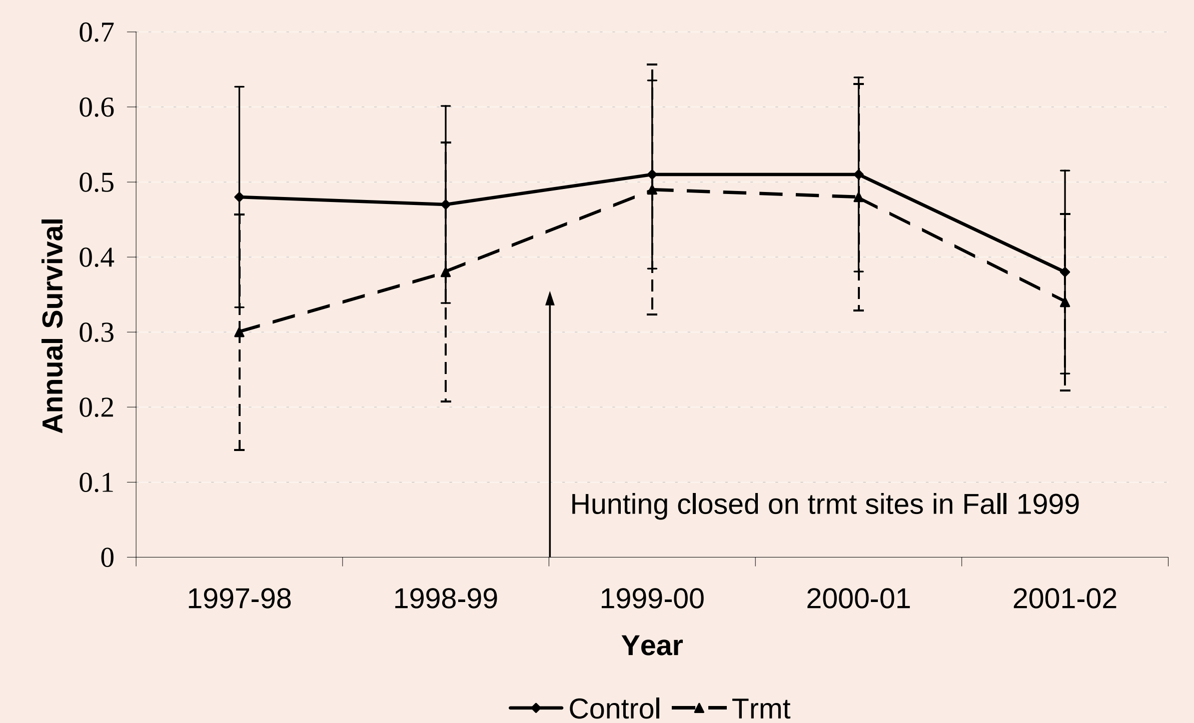


Figure 10. Ruffed grouse annual survival rates on control and treatment sites in the Appalachian region, 1997–2002. Vertical bars represent the 95% confidence interval on the estimates.

control and treatment sites, indicating regulated sport harvest did not cause a decrease in annual survival or abundance. Cessation of hunting on the 3 treatment sites did not result in increased annual survival among adult, juvenile, male, or female grouse. Harvest accounted for 12% of all known mortalities during the course of the study. Annual harvest rates ranged 0 – 35% and were lower than harvest rates reported in the core of ruffed grouse range, which may reach 50% or more. Hunting pressure on ACGRP study sites may have been influenced by publicity on the research project. Approximately 30% of the hunters interviewed on the WV2 site indicated they had never hunted there previously and had heard of the area through the research efforts (W. K. Igo, WVDNR unpublished data). Birds dispersing from the WV2 site had low hunter harvest rates (<3%, W. K. Igo, WVDNR, unpublished data). These survey data suggest that our harvest rates could be inflated because of increased effort at our study sites.

Ruffed grouse harvest was evenly distributed throughout the hunting season (Oct to mid-Feb) indicating harvest pressure was not greater in the late-season (Jan-Feb) than in the early-season (Oct-Dec). Observed harvest rates during this study were low compared to the Great Lakes region. Researchers in the Great Lakes region have concluded harvest mortality is compensatory and that grouse populations can support annual harvest rates between 30–50% of preseason population. Managers should be cautious in developing harvest regulations that increase harvest rates beyond those experienced during this study as harvest mortality above 30% may be additive.

Patrick Devers is a Ph.D. candidate at Virginia Tech studying ruffed grouse population ecology as part of the Appalachian Cooperative Grouse Research Project. He received his B.S. degree in wildlife biology from Colorado State University in 1997 and his M.S. in Renewable Natural Resources from the University of Arizona in 1999. Patrick will join the Conservation Management Institute at Virginia Tech after completing is degree in the fall of 2004. Pat's research interest include population ecology and monitoring, and the human dimensions of wildlife conservation.

SURVIVAL AND PREDATION

PREDATION ON ADULT RUFFED GROUSE IN THE APPALACHIANS

by: George Bumann and Dean F. Stauffer, Virginia Tech

Ruffed grouse in the Appalachian Mountains suffer their largest, natural losses to predation. Predation has resulted in behavior, physical attributes, and habitat use that reflect this long history with predatory animals. Quick flushing, wariness, agile flight, and cryptic coloration admired by the sporting and birding community alike, were developed in response, not to the dog and gun, but to hawks and foxes. The impact of predatory birds and mammals remains a prominent force in dictating the longevity of grouse in the wild.

The context in which one finds grouse is essential for understanding its relationship to predators of the region. Living on the southern tip of its distribution, the ecology and relation of grouse to predators in the Appalachians, differs from that of its northern relatives. The oak-hickory dominated forests of the southeastern U.S. lack persistent winter snows for snow roosting and predator avoidance, extensive aspen stands for escape cover and food, and periodic invasions by boreal birds-of-prey. Their use of moist hollows and rhododendron bottoms, ridge top mountain laurel, presence of annual migrations of birds-of-prey, in addition to regional trends in forest maturation, has important implications for the survival of adult grouse in the Appalachians.

Nearly all carnivorous animals in grouse range consume grouse as part of their diet. Some species come by a meal of grouse by accident while others appear to be more suited to the task of hunting ruffed grouse from the ground or air. Mammalian predator species including: red fox, gray fox, coyote, domestic dog, house cat, bobcat, raccoon, mink, weasel, fisher, striped skunk, opossum, and black bear, have been observed in and around AGCRP study sites. Avian predators present include: golden eagle, bald eagle, Cooper's hawk, sharp-shinned hawk, red-tailed hawk, red-shouldered hawk, broad-winged hawk, barred owl, great horned owl, and eastern screech owl. The Northern goshawk and great horned owls have been cited as skilled hunters of grouse yet the goshawk is largely absent from most of the Appalachians and most abundant during migration. ACGRP researchers reported fewer than 15 sightings of goshawks from February 1997 through December 2000.

Birds-of-prey are the most effective predators of ruffed grouse in the Appalachians. Other

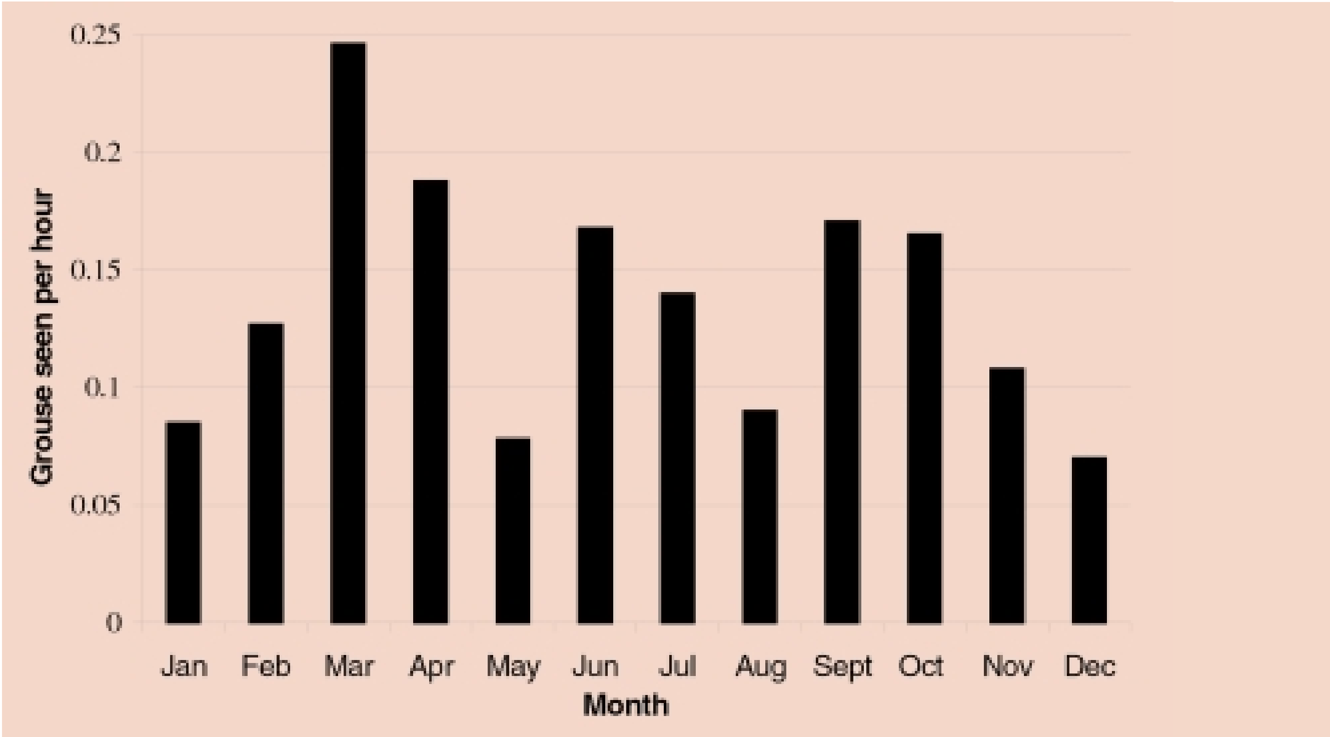


Figure 11. Summary of monthly observations ruffed grouse per hour across ACGRP sites from 1997 through 2000. Values are averaged across all study sites and all years.

investigations have indicated that mammal predators deserve credit for a significant portion of grouse death (especially with regard to nesting), yet our studies suggest that a large number of grouse assumed to have fallen prey to mammal predators may have initially succumbed to other causes such as hunter loss, accidental death, and hawk or owl predation. In this way, underestimation of the importance of raptors and overestimation of the role of mammal predators has likely occurred. Predation rates of raptors on grouse may actually be has high as 70–80% of all predation.

Other regions in the grouse range are impacted by periodic invasions by boreal hawks and owls, yet the Appalachians are too southerly to realize such affects. Alternately, spring and autumn raptor migration does result in seasonal increases in hawk and owl numbers. Fall movements also coincide with the fall brood break-up period when large numbers of inexperienced birds strike out on their own. Courtship and nesting activity in the spring also occur during the northward return of many migratory raptors; this coincidence results in the greatest proportion of the annual grouse population being visible and exposed to predation at this time (grouse numbers are at their annual low prior to the nesting season; Fig. 11). Understandably, peaks in predation on ruffed grouse, in the Appalachians, are situated during fall and spring, respectively (Fig. 12). September represents the month of greatest predator-related mortality in grouse. Predation rates drop during the winter months and then show a small peak in April. Despite the peak of predator observations occurring in sum-

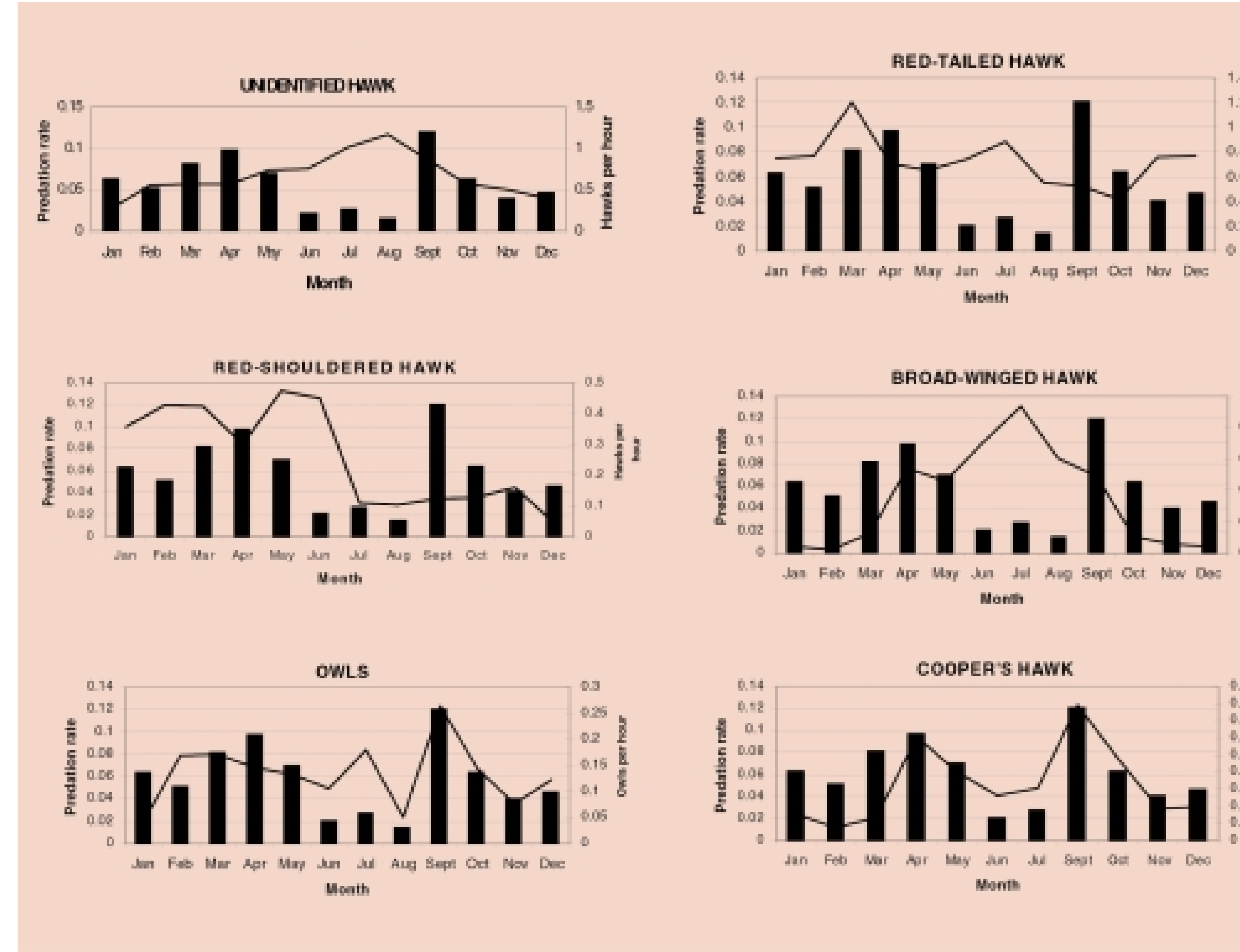


Figure 12. Monthly predation rate on ruffed grouse (vertical bars) and frequency of raptors (lines) observed by month pooled across sites and years in the Appalachians from 1997–2000.

mer (in large part due to repeat sightings of resident/nesting individuals and their young), this period represents a lull in predation on adult ruffed grouse.

The sporting public has long cited the coincidence of predator sightings and predation rates on game species however, empirical data supporting such assertions has been scarce. Over a period ranging from February 1997 through December 2000 ACGRP staff collected data to address the aforementioned issue. Grouse survival (monitored via radio-telemetry) and predator observations (4,281 sightings of species mentioned above) were logged during 43,994 hours of fieldwork and 207,332 miles of travel. The frequency of occurrence for our most important grouse predators (including red-tailed, red-shouldered, broad-winged, Cooper's hawks, and owls) was compared to the predation rates based on the survival component of the study. Increases in predation on ruffed grouse were only found to occur during increases in owl (both great horned and barred) and Cooper's hawk observations (Fig. 12); all other avian predator sightings did not show a relation to grouse deaths (Fig. 12). From these results it appears that although we know most predators kill grouse at one time or another, owls and Cooper's hawk sightings coincided with increases on grouse predation.

Predators have been, and will always be a prominent source of morality in grouse populations. For future management it should be noted that focusing on predation from a habitat standpoint may prove far more feasible and effective than managing predator populations. Beyond that fact that many grouse predators are federally protected species, predator control alone has proved ineffective for widespread improvement of the game crop. Focusing on habitat quality and especially juxtaposition may be the most effective means of managing predator effects on the grouse population of the Appalachians. Older, more aggressive individuals may prove fit to hold the preferred territories in the limited amounts of higher quality habitat. Birds that select for habit composed of moist bottomlands, thick rhododendron and laurel thickets, and regenerating stands of hardwood move less and survive longer. The risk of predation when a bird is traveling in search of mates, territory, quality forage, etc. is much higher than sedentary individuals. Ruffed grouse that can fulfill all, or most of their needs in one locality (including finding mates, food, escape cover, brood habitat, nest sites etc.) will tend to wander less and become more familiar with their surroundings, hence less susceptible to fall to predation.

George Bumann, M.S. is a graduate of Virginia Polytechnic Institute and State University. His graduate research, in conjunction with the Appalachian Cooperative Grouse Research Project, focused on the predator-prey relationships of ruffed grouse in that region. He currently works as an instructor of art and natural history for the Yellowstone Association Institute in Yellowstone National Park. His writing and illustrations have appeared in several popular and scientific publications and are featured in this report.

HABITAT USE

RUFFED GROUSE HABITAT SELECTION AND HOME RANGE SIZE IN THE APPALACHIAN REGION

by: Darroch M. Whitaker, Todd Fearer, Scott Haulton, and Dean F. Stauffer, Virginia Tech

HABITAT SELECTION AT CLINCH MOUNTAIN WMA, VIRGINIA

Throughout their range, ruffed grouse are considered to be birds that like early-successional habitats. Sites with high densities of small woody stems and well developed herbaceous cover are selected by ruffed grouse. These conditions typically are found in young clearcuts and stands younger than about 20 years old. In the Appalachians, we also observed a preference for sites with a high stem density. When we compared habitat selection within home ranges to that area immediately surrounding the home range, we found that regenerations sites (clearcuts) were the most preferred cover type,

Table 8. Ranked preference of cover types by ruffed grouse based on a compositional analysis for home range and study site scales. Data were collected on the Clinch Mountain Wildlife Management Area, Virginia, 1996–1998. The lowest rank (1) represents the most preferred habitat.

	Cover Types	
Rank	**Home range scale**	**Study site scale**
1	Regeneration cut	Mesic deciduous w / mixed understory
2	Mesic deciduous w / mixed understory	Mesic deciduous w / evergreen understory
3	Mesic deciduous w / evergreen understory	Regeneration cut
4	Meso-xeric deciduous	Meso-xeric deciduous w / mixed understory
5	Mesic deciduous	Mesic deciduous
6	Meso-xeric deciduous w / mixed understory	Meso-xeric deciduous
7	Xeric deciduous w / evergreen understory	Xeric deciduous w / evergreen understory
8	Xeric deciduous w / mixed understory	Meso-xeric deciduous w / evergreen understory
9	Meso-xeric deciduous w / evergreen understory	Xeric deciduous
10	Xeric deciduous	Mesic herbaceous
11	Mesic coniferous	Xeric deciduous w / mixed understory
12	Xeric coniferous	Meso-xeric coniferous
13	Mesic herbaceous	Xeric coniferous
14	Other	Mesic coniferous
15	Meso-xeric coniferous	Other

and that mesic deciduous sites with either mixed or evergreen (rhododendron and mountain laurel) understory were also preferred (Table 8). When comparing home range conditions to those present across the landscape, these same 3 cover types were preferred, but in a different order. These cover types provide high stem densities in the understories, indicating that when early successional habitats are not available, ruffed grouse will then use sites in mature forest that provide the structural conditions (high understory stem densities) found in early successional habitats.

Brood habitat – Brood cover is a critical component of ruffed grouse habitat during a period when chick mortality may be high. We intensively studied the microhabitat and insect populations used by 25 broods in three study areas (VA1, VA2, and WV2). We compared characteristics at ruffed grouse brood locations with random locations to determine characteristics selected by females with broods.

Females with broods used forested sites with a well-developed overstory canopy (>70%). These sites had a higher abundance of arthropods in the first 3-weeks after hatch, taller ground cover and higher percent ground cover in the first 6-weeks after hatch than random sites. Total woody stem densities did not differ between brood and random sites, as has been found in several studies from more northern sites. It appeared females with broods were selecting areas with abundant, tall herbaceous ground cover that provides substrate for the invertebrates that constitute a critical food source for chicks. Sites selected by broods had higher abundances of invertebrates of the orders Coleoptera, Homoptera and Arachnida than random sites.

ROOST SITES

In northern regions, ruffed grouse conserve considerable energy during winter by burrowing under snow cover to roost. When conditions are unsuitable for snow burrowing, grouse almost invariably roost in conifers. We studied selection of winter night roosts by ruffed grouse on 3 study sites (VA1, VA2, and VA3) in western Virginia, a region where snow accumulation is variable and generally transient. Grouse almost always used ground roosts when snow was present (20 of 25 roosts were on ground), even though snow was never deep enough for snow burrowing. When snow was absent, grouse did not show any clear preference in roost microsite type (59 roosts, 29 on ground and 30 above ground), and were found roosting in and under deciduous and evergreen trees and shrubs, in brush piles, and in leaf litter. We hypothesized that this ambivalence to conifers was due in part to ubiquitous and persistent accumulations of fallen oak leaves, which likely afford grouse good thermal cover and concealment. Ruffed grouse were commonly found foraging at low elevations during daytime, but almost invariably roosted on midslopes or ridges (Table 10). This suggests daily elevational movements, likely to avoid cold air settling in low-lying areas during the night.

HOME RANGE AND HABITAT SELECTION

We also assessed factors that affect home range size in ruffed grouse. As animals are typically under selective pressure to use the smallest ade-

Table 10. Slope position of daytime and nighttime (i.e., roosting) grouse locations at 3 study sites in western Virginia, 1998–2002. Divisions between midslope and toe / bottom, and between ridge and midslope were one-third and two-thirds of the way up slopes, respectively. Columns represent the number of locations with percent of time locations in parentheses.

Site	Time of Day	Toe/Bottom	Midslope	Ridge
VA1	Night	4 (9)	18 (39)	24 (52)
	Day	63 (42)	63 (42)	24 (16)
VA2	Night	0 (0)	19 (73)	7 (26)
	Day	33 (22)	69 (46)	48 (32)
VA3	Night	4 (24)	6 (35)	7 (41)
	Day	43 (29)	51 (34)	56 (37)
Total	Night	8 (9)	43 (48)	38 (43)
	Day	139 (31)	183 (41)	128 (28)

quate home range, identifying factors associated with variability in home range size can provide important insight into a species' habitat ecology. We monitored 1,519 grouse at 10 study sites using radio-telemetry. We used 67,814 locations of radio-marked grouse to delineate 647 fall-winter (Oct-Mar) and 407 spring-summer (Apr-Sep) home ranges of ruffed grouse (Fig 13). Mean seasonal home range size differed by age and sex class (Table 10). Females that occupied smaller fall-winter home ranges were more likely to reproduce successfully during spring, and other researchers have reported higher survival for ruffed grouse using smaller ranges, supporting our assumption that home range size was inversely related to fitness.

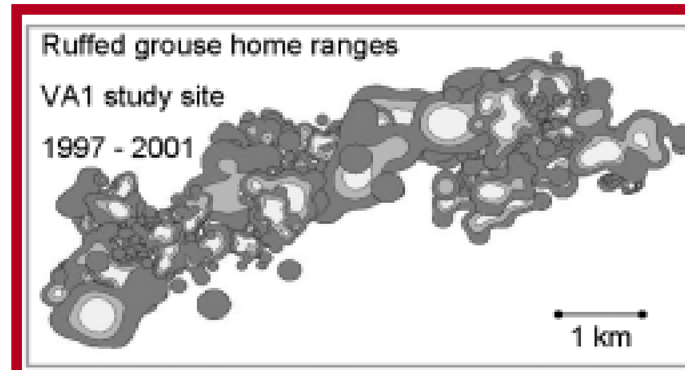


Figure 13. Home ranges of ruffed grouse monitored the Deerfield Site (VA1) in Augusta County Virginia, 1997–2001. Grouse home ranges were centered in the white areas where they were found most frequently (50% kernel home range). The lighter and darker green areas surrounding the 50% kernel home range represented the 75% and 95% kernel home range areas.

Numerous factors were associated with variation in home range size. Females and juvenile males occupied ≥2¥ larger home ranges than adult males, and female home ranges averaged 2.6¥ larger during breeding seasons when they successfully reared broods (39.2 ha, 75% kernel) than when they experienced reproductive failure (14.8 ha). Home range size of juvenile males was positively related to population density, supporting the hypothesis that they are in competition with established males for preferred territories. Clearcuts and forest roads generally are viewed

Table 11. Mean extent (ha) of 75% fixed kernel home ranges occupied by ruffed grouse during fall-winter (Oct–Mar) and spring-summer (Apr–Sep) at 10 study sites in the Appalachians, 1996–2001.

	Juvenile Females			Adult Females			Juvenile Males			Adult Males		
Forest Association	***n***	**Mean**	**SE**	***n***	**Mean**	**SE**	***n***	**Mean**	**SE**	***n***	**Mean**	**SE**
Oak-hickory												
Fall-Winter	5	32.7	8.5	5	32.1	4.2	5	29.7	9.1	5	12.4	2.4
Oak-hickory												
Spring-Summer	5	33.2	12.3	5	26.3	2.7	5	12.2	2.5	5	9.8	2.0
Mixed-mesopphytic												
Fall- Winter	5	26.1	3.8	5	20.2	4.9	4	26.1	4.2	5	12.1	1.5
Mixed-mesopphytic												
Spring-Summer	5	22.2	4.7	5	22.7	4.7	4	11.5	2.9	4	7.9	1.9
Regional												
Fall-Winter	10	29.8	4.9	10	26.2	3.6	9	28.1	5.1	10	12.2	1.3
Regional												
Spring-Summer	10	27.7	6.5	10	24.5	2.6	9	11.9	1.8	9	8.9	1.4

as providing high quality grouse covers, and both were more prevalent in smaller home ranges. In oak-hickory forests, female home range size was inversely related to proportional coverage of mesic bottomlands, which support relatively abundant herbaceous plant foods. Home ranges of males and females inhabiting oak-hickory forests increased 2.5¥ following poor fall acorn crops; with male 75% kernel home ranges increasing from 7.3 ha to 22.3 ha, and those of females increasing from 19.7 ha to 51.6 ha. In contrast, home ranges of ruffed grouse inhabiting mixed-mesophytic forests were unaffected by these factors. This supports the view that grouse populations in many Appalachian forests are under strong nutritional constraint and that good foraging habitats are localized. However, more dependable alternate foods (e.g., cherry and birch buds) may relax these constraints in mixed-mesophytic forests. Finally, all sex and age classes of grouse used smaller home ranges following closure of sites to grouse hunting, suggesting that hunters displace grouse from preferred habitats, at least temporarily.

A goal of many habitat studies is the identification of selected habitat features. However, favorability of a particular habitat type is likely contingent on such factors as landscape composition, predation risk, and an individual's immediate resource needs, so will vary depending on context. Identifying factors associated with variation in strength of selection for "preferred" habitat features could increase our understanding of functional aspects of a species' habitat ecology, for example by indicating when and why a habitat feature is important. It is widely recognized that clearcuts afford important escape cover for ruffed grouse, while access routes (roads) and mesic bottomlands are viewed as important foraging areas. Selection towards clear-cuts, access routes, and mesic bottomlands was interdependent; selection for clearcuts was positively related to selection for access routes, but negatively related to selection for mesic bottomlands. Ruffed grouse selected either clearcuts or for mesic bottomlands, but not both at the same time. Selection for mesic bottomlands and selection for access routes were positively related in oak-hickory forests, but unrelated in mixed-mesophytic forests. Other differences in selectivity were noted between these two forest types; clearcuts were more strongly selected in mixed-mesophytic forests, whereas mesic bottomlands were only selected in oak-hickory forests. Following poor fall hard mast crops, selection for access routes by female grouse increased. Strength of selection for all 3 habitat features was increased following closure of sites to hunting, suggesting that hunters discouraged use of otherwise preferred cover types. Taken together, our observations suggest that individual grouse make a tradeoff between favoring either survival or condition to maximize fitness, with males favoring refuging habitats, and females favoring foraging habitats. From this and other ACGRP studies (see sections by B. Long and P. Devers, this report) it is clear ruffed grouse endure considerable nutritional stress in oak-hickory forests, so they must seek out the best foraging sites and are particularly sensitive to size of fall acorn crops. In contrast, in mixed-mesophytic forests, where nutritional constraint is relaxed, all sex and age classes of grouse made greater use of escape cover (i.e., clearcuts).

Darroch Whitaker received his Ph.D. in wildlife science from Virginia Tech in 2003 studying ruffed grouse habitat selection in the Appalachians as part of the Appalachian Cooperative Grouse Research Project and is currently working as a Post-Doctorate at Arcadia University, Novia Scotia studying song bird communities. Darroch received a M.S. in Biopsychology from Memorial University of Newfoundland in 1996 and a B.S. in Resource Conservation and Environmental Forestry in 1994 from McGill University. Darroch's research interests wildlife conservation in managed forests, resource selection, and animal movements.

Todd Fearer graduated from Penn State in December of 1995 with a Bachelor of Science degree in Wildlife and Fisheries Science and minors in Forestry Science and International

Agriculture. He received his Master of Science degree in Wildlife Science from Virginia Tech in June of 1999. His research was part of the Appalachian Cooperative Research Project and focused on the relationship of ruffed grouse home range size and movement to landscape characteristics. He is currently pursuing a PhD at Virginia Tech where he is evaluating population-habitat relationships of forest breeding birds at multiple scales using Forest Inventory and Analysis data. His research interests include landscape ecology, GIS, upland gamebird ecology and management, conservation and management of early successional habitats, and forest-wildlife habitat relationships in oak forest ecosystems.

Scott Haulton is originally from upstate New York, were he received a B.A. in English and a B.S. in Environmental and Forest Biology. He attended Virginia Tech where he received a M.S. in Wildlife Science and studied ruffed grouse population ecology in managed forests in Virginia and West Virginia. After graduating, Scott worked briefly with DuPage County (IL) Forest Preserve District where he supervised their deer population management and browse monitoring program. In 2000 Scott returned to his home state, working with the State University of NY College of Environmental Science and Forestry's Adirondack Ecological Center in the Adirondack Mountains of northern New York. He developed research projects that investigated the effects of forest management on wildlife populations and habitats and the impacts of deer and beaver herbivory on forest development. Scott is presently working with the Will County (IL) Forest Preserve District, where he continues his work with land management, deer population management, and monitoring the effects of herbivory on forested communities.

HABITAT USE

USE OF ELEVATION BY RUFFED GROUSE IN VIRGINIA AND PENNSYLVANIA

by: Joy O'Keefe and Steve Sumithran, Eastern Kentucky University

In the Appalachian region, ruffed grouse are found in rugged lands and usually at higher elevations. Drumming males preferred to display at sites on upper slopes or forest ridges. In winter, grouse varied their use of elevation on a daily basis in southwestern Virginia; birds moved upslope at night to avoid thermal inversions of cold air, which often settle in the mesic hollows where grouse feed during the day. The goal of this study as part of the ACGRP was to investigate ruffed grouse use and selection of elevation in the Appalachian region on 4 study sites (PA1, VA1, VA2, and VA3).

There were differences in use of elevation by sex and by age for Appalachian ruffed grouse in Virginia and Pennsylvania. Preferred elevation classes were typically mid to high elevation classes that also accounted for most of the available habitat at each site. Landcover may factor into these results, as clearcuts were often found in large proportions in the highest elevation classes at each site.

Season did not have an effect on use of elevation by ruffed grouse at any of the 4 study sites. Although ruffed grouse do not exhibit large-scale migratory moves, like some other gallinaceous birds, seasonal differences in their movements have been documented. We did not find an effect of age or sex on use of elevation by ruffed grouse at the VA1 study site. However, age was a significant factor at the VA3 site, and sex and age were significant factors in use of elevation for birds at PA1 and VA2. The combined effects of sex and age on use of elevation observed in this study correspond with existing

data on the ecology of ruffed grouse. Fall dispersal could account for some of the variability in use of elevation by juveniles, which tended to be distributed across a greater range of elevations than adults. Further, juveniles may move into lower quality habitat if higher quality habitat are occupied by higher ranking adult grouse. Adult males may exclude juvenile males from preferred ridgetop drumming sites. This behavior could explain the age-specific difference in preference for lower elevation classes at the VA3 study site.

Some of the sex-specific differences in use of elevation noted in this study may be explained by the tendency for females to make greater movements than males as they select breeding sites, brood habitat, and wintering areas. At sites classified as oak-hickory forest, hens with chicks may move to lower elevations to take advantage of mesic foraging conditions in local hollows (D. Whitaker. 2003. pers. comm.). Females were found more often at the lowest elevation class than males of the same age group.

Land managers should consider the age and sex-specific differences in use of elevation by ruffed grouse in the Appalachians when implementing silvicultural treatments. Distributing clearcuts among multiple elevation classes with some semblance of connectivity between clearcuts might make them more accessible to subdominant juveniles that may be forced down to lower levels. At all elevation classes, land managers should strive to maintain an interspersion of multiple cover types of various sizes and shapes to maximize suitability for ruffed grouse.

Joy O'Keefe is a graduate student at Clemson University in SC, studying bat communities in the mountains of NC. Before coming to Clemson, Joy worked as a biologist and environmental educator with East Kentucky Power in Winchester, KY. In addition, Joy completed her master's degree at Eastern Kentucky University, studying the use of elevation by Appalachian ruffed grouse as part of the ACGRP. Joy has developed a passion for sharing her knowledge and learning more about the diverse natural resources of the Southeast.

MANAGEMENT RECOMMENDATIONS

POPULATION MANAGEMENT

By: Patrick K. Devers, Dean Stauffer, and Gary W. Norman

A primary goal of the ACGRP was to identify factors limiting ruffed grouse populations, with particular emphasis on determining the role of harvest in population dynamics. The experimental design of the ACGRP provided a unique opportunity to investigate the influence of harvest on ruffed grouse population dynamics and supported the hypothesis that harvest mortality is compensatory. This finding indicates current harvest regulations and seasons are not limiting populations. It is important to note the harvest rates observed in this study were low compared to published rates and may be an important factor in our determination of harvest mortality being compensatory. Furthermore, our harvest rates may have been inflated as some hunters hunted our study sites because of the ongoing research (W.K. Igo, WVDNR, unpublished data). The highest annual harvest rate was 30%, which is commonly suggested as a minimum sustainable harvest rate in the Great Lakes region. We urge caution in establishing harvest regulation that will facilitate harvest rates beyond 30% because we cannot assume our finding of compensatory mortality will hold above 30% harvest mortality rates. Though our findings indicated harvest mortality is compensatory, we also found evidence that hunter disturbance may alter ruffed grouse habitat selection which may ultimately reduce ruffed grouse productivity and survival. Based on these results, managers should gate or otherwise limit access to key grouse habitats on public areas with higher hunting pressure.

Beyond regulated sport harvest, our findings suggest ruffed grouse experience different selective pressures on oak-hickory forests and mixed-mesophytic forests. Ruffed grouse on oak-hickory forests exhibit higher survival than reported in the core of the species range, but also exhibit extremely poor productivity. In contrast, ruffed grouse on mixed-mesophytic forests exhibit survival and productivity rates similar to those reported in the Great Lakes States and Canada. Most notable of our findings was the relationship between mast production, female pre-breeding condition, and productivity, particularly chick survival. Though mast production was correlated with female pre-breeding condition and reproduction on both oak-hickory and mixed-mesophytic forest, the relationship appears to be stronger on oak-hickory forests.

HABITAT MANAGEMENT

By: Ben Jones and Craig Harper, University of Tennessee and Darroch Whitaker, Virginia Tech

ACGRP studies have identified a need to intersperse habitat types when managing for ruffed grouse. Important components of grouse habitat in the Appalachian region include mesic stands with herbaceous ground cover, early successional stands with high stem densities, mature stands with mast producing trees, and forest roads with abundant legumes and other forbs. In his work published in 1972, Gordon Gullion outlined a forest management system that created a diversity of habitats favored by ruffed grouse in the Great Lakes region. Although the general framework is applicable, there are major differences between aspen-dominated stands and those forest types found in the Appalachians.

To maintain optimal grouse habitat, managers should concentrate on providing quality cover and food, juxtaposed to reduce necessary travel. In the Lake States, both requirements are met through even-aged management of aspen. Following Gullion's recommendation, a patchwork of small clearcuts implemented at 10-year intervals over a 40-year rotation maximized grouse density. In Appalachian forests, where aspen is largely absent and timber rotations are much longer (80–120 years), managers face a more daunting task of providing quality cover and diverse food resources over space and time. Still, maintenance of young stands interspersed among other successional stages and important habitat features is critical.

A most-important challenge for managers in the Appalachian region is to evaluate forest management systems and select techniques most effective in producing grouse habitat. Forest management systems are generally not limited on most private, industrial, and state-owned lands. However, public opinions about forest management practices often influence forest management policies on federal lands. Fortunately, several regeneration techniques can be used to improve grouse habitat depending on goals, sites conditions, and public comment.

CLEARCUT

An important feature of ruffed grouse habitat is stands with a high midstory stem density, which provide protective cover and, ideally, offer good foraging opportunities. Most clearcut stands are optimal for grouse from 6–20 years after regeneration, depending on the site. Consequently, clearcutting has often been advocated as the best silvicultural option for improving grouse habitat.

In mixed-mesophytic and northern hardwood forests, buds should provide grouse a stable supply of high-quality winter foods in regenerating clearcuts, and in these forest types, clearcutting is likely the most appropriate silvicultural method to improve habitat for ruffed grouse. In oak-hickory forests, hard mast (acorns and beechnuts) is a critical winter food for grouse. Clearcutting these forests creates early successional habitat, but limits mast production for a number of years. Therefore, it is important to juxtapose mature oak stands adjacent to clearcuts so foraging opportunities for acorns and other mast are not limited. Where advanced oak regeneration is found, clearcutting is an effective system for regenerating oak-hickory forests.

SHELTERWOOD

The shelterwood method has received considerable attention as a technique for regenerating oak and mixed hardwoods. Shelterwood cuts in hardwood stands typically occur in two or more stages – an initial cutting to establish a new age-class of regeneration and two or more removal cuts to release regeneration and provide for its development. In hardwood forests, shelterwood methods range from techniques carefully designed to control species composition (especially oaks), to more general applications in which variable numbers of trees are retained and stand conditions resemble those achieved through clearcutting.

Shelterwood cuts can benefit grouse in several ways. First, opening the forest canopy increases herbaceous groundcover, creating important brood and foraging habitat. Soft mast production is increased the first few years after harvest, providing an important food source, and midstory stem density increases later in the rotation, providing escape cover. Another benefit of the shelterwood method is retention of oak for a period of time in the current stand, and provision for oak regeneration in the future. Acorns are an important food for Appalachian grouse. Therefore, stands with mature oaks are a critical habitat component in the region. In North Carolina, radio-tagged grouse began using shelterwood stands 6 years after initial harvest, prior to removal of residual canopy trees (Fig. 13).

Although shelterwood systems can improve habitat, there are many factors to consider. On mesic sites, herbaceous groundcover conditions will be improved, though species such as yellow poplar and birch tend to outcompete oak regeneration. Despite a lack of oak in the future stand, presence of birch buds (an important winter food source) and herbaceous groundcover improve foraging habitat. To regenerate oak on mesic sites, a shelterwood cut that controls midstory and lower canopy density but leaves the main canopy closed has been shown to foster development of advanced oak reproduction, a prerequisite for oak regeneration. On somewhat less mesic sites where yellow poplar is a competitor, a shelterwood cut

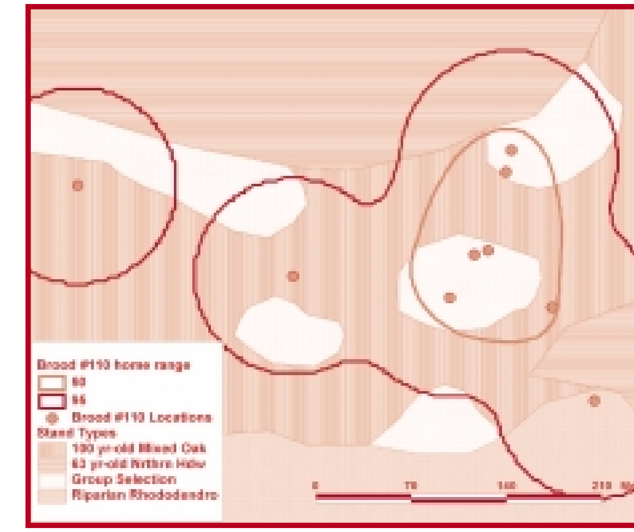


Figure 13. Kernel home range and locations of a ruffed grouse hen that used a 6-year-old shelterwood from October through February 2002 on the NC1 site, Macon County, North Carolina.

followed by prescribed fire or herbicide treatment has shown promise.

On dry sites, establishment of oak regeneration is less difficult. Although herbaceous groundcover will be less abundant, several species of oak including white oak, chestnut oak, black oak, and scarlet oak reproduce vigorously. Because of differences in acorn production among oaks, species diversity decreases the probability of complete hard mast failure in any given year.

TWO-AGE

The goal of the two-age method is to reduce basal area sufficiently in 1 or 2 cuts to provide for long-term development of regeneration while retaining some residual trees. A retention target of 20 sq ft / acre in dominant, co-dominant, and good intermediate crown class trees is typical. As the name implies, residual trees are retained beyond the normal period of retention for a conventional shelterwood, resulting in two distinct age classes.

The method used to create two-aged stands is often referred to as “shelterwood with reserves.”

Retention of hard-mast producing trees makes the two-age approach a beneficial system for grouse. Following traditional clearcutting, there is a time lag in hard mast production while trees mature (at least 30 – 40 years). Over that period, grouse must strike a balance between time spent in early successional cover and time spent foraging among mature oaks. The two-age technique provides food and cover within the same stand, allowing grouse to forage on acorns without increasing predation risk. Other preferred grouse foods also increase. In West Virginia, dogwood, serviceberry, and pin cherry were present in two-age stands, and grape vines occurred in 58 percent of the co-dominant reproduction stems.

Similar to shelterwoods, grouse began using two-age stands on the North Carolina study site at 6 years post-harvest. Most use occurred from October through January. In May 2004 (7 years after harvest), a radio-tagged hen hatched a clutch in a two-age stand, and as this report went to press was raising her brood in an adjacent 75-year-old oak stand.

GROUP SELECTION

Group selection is a method that harvests groups of trees within a stand over time, creating a mosaic of small even-aged patches. With group selection, managers can maintain a percentage of early successional habitat across the stand while avoiding visual impacts of large clearcuts. Size of group harvests ranges from a small area occupied by a few trees to approximately 2 acres.

Reports of vegetation response to group selection cutting differ among Appalachian regions. In the central Appalachians, group size appears to determine stand composition and structure. As cut size increases, regeneration is dominated by shade intolerant species such as yellow poplar, while shade tolerant (sugar maple, beech) and intermediate species (oaks, hickory) fare better in small groups. However, in the southern Appalachians, yellow poplar, sweet birch, and red maple sprouts dominated regeneration in small group openings (<0.2 acres) on mesic sites.

Managers also must decide on the number or density of group selection cuts to place in a given stand. Specific information on this topic is not currently available, though the density of cuts should be low if the character of a mature stand must be maintained. Creation of one patch cut per 10 acres would place patches approximately 800 feet apart, and harvesting would remove 2.5 – 6.25 percent of the stand. Thus, grouse would be able to remain within about 400 feet of escape cover when foraging in a mature stand.

Regarding forest management for grouse, a primary concern is that group selection creates isolated pockets of habitat. A potential solution is to thin residual stands between groups. Thinning can soften edge effects and provide improved

habitat conditions and connectivity between groups. Groups themselves also may serve as travel corridors. If positioned appropriately on the landscape, groups can provide patches of cover connecting otherwise disjunct habitats.

Group selection may be most useful in improving brood habitat. In North Carolina, brooding hens used edges of group cuts 4 years after harvest (Fig. 14). These groups contained abundant groundcover and were located within 80+ -year-old mixed oak stands – an important forest type for broods on the area. In addition, broods that used mixed oak stands lacking group cuts were often associated with canopy gaps, suggesting group harvests would be appropriate for enhancing brooding cover in these areas.

Figure 14. Kernel home range and locations of a grouse brood that used group selection cuts during the first 2 weeks post-hatch on the NC1 site, Macon County, North Carolina.

SIZE, SHAPE, AND PLACEMENT OF CUTS

There is a confusing abundance of literature concerning the optimal size of cuts for ruffed grouse. Cuts less than 2 acres have been recommended to improve brood habitat. Most authors report regenerating stands 1–25 acres in size are heavily used by grouse, allowing good interspersion of early successional habitats with other important features. Taking harvesting economics into account, some recommend larger cuts, up to 40 acres for oak-hickory forests. It seems grouse will use any size stand large enough to allow regeneration and recommending a single optimal size of cut is unwarranted. There are operational factors that need to be considered, but providing regenerating cover in a variety of sizes, ranging from 2–40 acres is most reasonable. Ultimately, the most important consideration is to maximize the availability of early successional forest cover throughout the landscape (within the bounds of the forest’s capacity and rotation period), and the decision to create more small cuts or fewer larger ones is of lesser importance.

Little information is available regarding the most appropriate shape and placement of cuts for grouse. However, ACGRP research indicated grouse home ranges were smaller, suggesting higher habitat quality, if they contained regularly shaped cuts (when cuts were 12 acres or less). The position of cuts is largely dependent upon the forest type and site; however, positioning harvests in the mid-slope can provide important escape cover for grouse traveling between ridge-top drumming sites, roost sites, and bottomland foraging sites. Another most important consideration is to regenerate or, at least, thin stands along riparian zones, which are preferred habitats for ruffed grouse during winter and summer when a dense stem density is present.

PRESCRIBED FIRE

Although once commonly used, fire has been suppressed in the Appalachian region for some 80 years, altering many of the associated forest types and wildlife communities. Fortunately, forest and wildlife managers are realizing the positive benefits of fire and using it more often in Appalachian forests, especially to reduce fuels and foster oak regeneration as discussed previously. This has proven beneficial for ruffed grouse, particularly in oak-hickory forests where controlled burning can enhance brooding habitat.

On the North Carolina study site, fire was prescribed on an area primarily consisting of oak-hickory forest in March 2002. By 2004, the treated area (approximately 700 acres) supported a diverse herbaceous community, which was used almost exclusively by several grouse broods. Researchers in West Virginia also reported positive results with prescribed fire. Grouse broods in the Appalachians selected areas with abundant herbaceous vegetation, especially forb and fern cover, but also low-growing woody cover, such as blueberries and huckleberries. Brooding sites harbored more invertebrates than random sites, which provided a critical food source with available cover.

Prescribed fire in the Appalachians is restricted primarily to oak-hickory forests and other forest types associated with southern and western exposures and ridgetops. This offers numerous opportunities for habitat enhancement, especially where oak-hickory forests comprise 50 percent or more of the available forest cover. When burning oak-hickory stands, fire often feathers into coves and more mesic forests types, but intensity is much less and these areas rarely burn. In fact, when burning relatively large areas (200 – 500 acres; which is usually necessary on national forests where there is a lack of roads or firebreaks), coves, creeks, and northern / eastern exposures are commonly used as natural firebreaks. This provides an exceptional mosaic of conditions across the burned area, which is quite favorable for ruffed grouse.

Fire intensity is determined by fuel load and moisture content, wind, humidity, temperature, and atmospheric conditions. Managers should balance fire intensity with existing site conditions to create the desired habitat structure and composition. For example, a relatively cool fire may be used to consume the litter layer and promote an herbaceous understory, while a hot fire is necessary to reduce extensive coverage of mountain laurel and allow adequate light to the forest floor to stimulate the seedbank. Depending on stocking and percent canopy cover, thinning is sometimes desirable prior to burning. Basal area will fluctuate among sites, but reducing canopy closure to 60 – 80 percent should allow sufficient sunlight into the forest floor to develop the desired understory structure for brooding habitat and promote additional soft mast production.

The vast majority of burns in the Appalachians are prescribed during the dormant season, usually in late winter. Burning should be completed prior to nest initiation, which normally occurs in early- to mid-April in the Appalachians. This is quite important as the re-nesting rate for grouse on several of the ACGRP study sites was very low.

The historical occurrence of fire in the Appalachian region has been debated, but most researchers agree lightning- and Indian-ignited fires probably occurred every 3 – 25 years in those stands that would burn, depending on the site and climatic conditions. As related to habitat management for grouse, the structure and composition of the understory and midstory, fuel load, and the site determine fire rotation. On drier sites, it is not unusual for woody species to dominate the understory, while the understory on more mesic sites usually has a greater percentage of herbaceous cover. This can influence fire rotation. More frequent fire (every 2–4 years) on drier sites can be used to stimulate increased herbaceous cover.

FOREST ROADS

Forest roads (access routes) can provide important grouse habitat in the Appalachians. When seeded properly, access routes provide foraging areas, especially during years with a low mast crop. ACGRP studies found hens selected forest roads during fall and winter and during the breeding season. Therefore, roads should provide a nutritional food source during these times.

Grouse crops collected as part of the ACGRP study contained herbaceous material, dominated by clover, cinquefoil, birdsfoot trefoil, coltsfoot, and wild strawberry. Although orchardgrass was the predominant cover type on many forest roads, no orchardgrass was found in any of the grouse crops. In fact, of 326 crops examined from 6 states, no grass of any kind was found in measurable amounts. From this study, it is apparent access roads dominated by legumes and other forbs are most beneficial to grouse.

Many forbs are available in the seedbank, and managers can save time and money by taking advantage of this natural seed source. Following road closure, a good approach is to plant a mixture of clover and birdsfoot trefoil with an annual grass to stabilize soil – winter wheat is a popular choice because it is winter hardy and provides a desirable seed source. In acidic soils (pH<5.8), liming is necessary to retain clover and birdsfoot trefoil. Over time, pH will decrease and naturally occurring forbs from the seedbank will replace the planted legumes. Because of their tendency to out-compete clovers, perennial cool-season grasses (including tall fescue, orchardgrass, bromes, bluegrass, and timothy) should be avoided. Further, perennial cool-season grasses harbor fewer invertebrates, develop a dense structure and deep thatch that inhibits travel by broods, and provide a poor seed source when compared to planted legumes and naturally occurring forbs and grasses. The following seeding rate (per acre), has shown excellent results: 4 lbs. ladino white clover, 2 lbs. white-dutch clover, 2 lbs. birdsfoot trefoil, 40 lbs. wheat.

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Penn State, and M.S. degree in Wildlife and Fisheries Science from Mississippi State University. He is currently studying ruffed grouse use of forest stands harvested via alternative regeneration techniques in western North Carolina. Research interests include impacts of silvicultural prescriptions on wildlife and the use of forest management for improving wildlife habitat.

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APPENDIX

Common and scientific names of animals and plants mentioned in the report.

Common Name	*Scientific Name*
MAMMALS	
Black bear	*Ursus americanus*
Bobcat	*Lynx rufus*
Coyote	*Canis latrans*
Domestic dog	*C. familiaris*
Eastern chipmunk	*Tamia striatus*
Fisher	*Martes pennanti*
Gray fox	*Urocyon cinereoargenteus*
House cat	*Felis catus*
Mink	*Mustela vison*
Opossum	*Didelphis virginiana*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Shrew	*Sorex* spp.
Striped skunk	*Mephitis mephitis*
Weasel	
BIRDS	
Bald eagle	*Haliaeetus leucocephalus*
Barred owl	*Strix varia*
Broad-winged hawk	*Buteo platypterus*
Cooper’s hawk	*Accipiter cooperii*
Eastern screech owl	*Otus asio*
Golden eagle	*Aquila chrysaetos*
Great horned owl	*Bubo virginianus*
Northern goshawk	*Accipiter. gentilis*
Red-shouldered hawk	*Buteo. lineatus*
Red-tailed hawk	*Buteo. jamaicensis*
Ruffed grouse	*Bonasa umbellus*
Sharp-shinned hawk	*Accipiter striatus*
REPTILES	
Black rat snake	*Elaphe obsoletus*
TREES AND SHRUBS	
Alder	*Alnus* spp.
Aspen	*Populus tremuloides*
Azalea	*Rhododendron* spp.
Basswood	*Tilia americana*
Beech	*Fagus grandifolia*
Birch, black	*Betula lenta*
Birch, yellow	*B. alleghaniensis*
Blueberry	*Vaccinium* spp
Cherry, black	*Prunus serotina*
Cherry, pin	*P. pensylvanica*
Eastern hemlock	*Tsuga canadensis*
Grape	*Vitis* spp.
Great rhododendron	*Rhododendron maximum*
Greenbriar	*Smilax* spp.
Hickory, bitternut	*Carya cordiformis*
Hickory, mockernut	*C. tomentosa*
Hickory, pignut	*C. glabra*
Hickory, shagbark	*C. ovata*
Hornbeam	Ostrya virginiana
Huckleberry	Baylussacia *spp.*
Maple, red	*Acer rubrum*
Maple, striped	*A. pensylvanicum*
Maple, sugar	*A. saccharum*
Mountain laurel	*Kalmia latifolia*
Multiflora rose	*Rosa multiflora*
Oak, black	*Quercus velutina*
Oak, chestnut	*Q. prinus*
Oak, northern red	*Q. rubra*
Oak, scarlet	*Q. coccinea*
Oak, white	*Q. alba*
Pine, pitch	*Pinus rigida*
Pine, table mountain	*P. pungens*
Pine, Virginia	*P. virginiana*
Pine, white	*P. strobus*
Serviceberry	*Amelanchier* spp.
Sumac	*Rhus* spp.
Yellow poplar	*Liriodendron tulipifera*
White ash	*Fraxinus americana*
Witch hazel	*Hamamelis virginiana*
HERBACEOUS PLANTS	
Avens	*Geum* spp.
Birdsfoot-trefoil	*Lotus corniculatus*
Christmas fern	*Polystichum acrostichoides*
Cinquefoil	*Potentilla* spp.
Clover	*Trifolium* spp.
Coltsfoot	*Tussilago farfara*
Dewberry	*Rubus hispidus*
Hawkweed	*Hieracium* spp.
Orchardgrass	*Dactylus glomerata*
Partridgeberry	*Mitchella repens*
Pyrola	*Pyrola* spp.
Sorrel	*Rumex acetosella*
Strawberry	*Fragaria* spp.
Trailing arbutus	*Epigaea repens*
Viburnum	*Viburnum* spp.
Wintergreen	*Gaultheria procumbens*
Wood fern	*Dryopteris camyloptera*

ACGRP Cooperators